THE OHIO JOURNAL OF SCIENCE

VOL. LII SEPTEMBER, 1952 No. 5

THE UNDERGRADUATE PHYSICS CURRICULUM

A SYMPOSIUM on "The Undergraduate Physics Curriculum" was held under the joint sponsorship of Section F of the Ohio Academy of Science and the Ohio Section of the American Physical Society, at Miami University, Oxford, Ohio, April 7, 1951.

Moderator: Forrest Tucker.

Participants: T. D. Phillips, Dudley Williams, J. F. Eichelberger, R. L. Edwards.

PHYSICS IN THE LIBERAL ARTS COLLEGE

THOMAS D. PHILLIPS

Department of Physics, Marietta College, Marietta, Ohio

This is an inventory and an evaluation. It is a report of what we teachers of Physics in Ohio colleges think we should be doing. To find your opinions, and my own, I did not send out any questionnaires. If I had, I might have found out what we think we ought to think, but hardly what we do think. What we really think is written in the catalogues of our respective colleges under the heading COURSES IN PHYSICS. These are opinions on which we are prepared to act. In the case of Marietta College catalogue I should use the past tense. Whether anything else comes of this paper or not, the preparation of it has produced radical changes in my own thinking which will result in considerable revision of the next printing of our catalogue.

It is a well-known rule of investigation that it is easier to find answers if you have questions. In making this survey of opinions I examined the catalogues of forty Ohio colleges and sought answers to the following questions:

1. *Question.* What do we think is the main business of the college physics teacher?

Answer. The preparation of professional physicists (unanimous).

2. *Question.* What undergraduate work should be done by the future physicist?

Answer. Twenty-four to forty hours of physics and mathematics through calculus (90 percent of the schools). There is wide variation, however, in the timing of the mathematics. In some schools calculus must be taken concurrently with the first course in physics and some advanced courses have differential equations and advanced calculus as prerequisites. In a few schools, the entire physics sequence can be completed without going beyond trigonometry in mathematics.

3. *Question.* What kind of course should be offered to meet the "eight hours of physics" required for entrance to medical schools?

Answer. No special course (95%). Standard physics course with slight modifications (5%). Course specifically for premedical needs (none). In a

majority of the schools two introductory courses in physics are offered, one for "science" students and one for "arts" or non-science students. It is either stated or implied that the pre-medical students will take the non-science course. Usually this non-science course is described in negative terms. It is less mathematical, less laboratory, less in prerequisites.

4. *Question.* What responsibility have we to provide for the training of high school teachers of physics?

Answer. None (90%). Course in methods of teaching physics (10%).

5. *Question.* Should college physics courses take any recognition of work previously done in high school physics courses?

Answer. No (90%).

6. *Question.* Should courses be offered directly relating the methods, skills, and subject matter of physics to other sciences such as, chemical physics, geophysics, biophysics, psychophysics?

Answer. No (97%). In 10 percent of the schools there are, however, courses in laboratory arts such as glass-blowing and photography.

7. *Question.* Should courses in physics be offered directly relating the subject matter of physics to certain arts such as music and painting?

Answer. No (85%). The yes vote is largely due to courses in the physical theory of music. Some of these attempt to save face by using the title "acoustics."

8. *Question.* Should "how it works" courses be offered which deal directly with everyday gadgetry?

Answer. No (100%). A very few colleges offer courses in household physics and some of these may be directed toward the "how it works" goal.

9. *Question.* Is there any place for a course in physics whose primary goal is esthetic appreciation and personal orientation?

Answer. As a secondary goal, yes (25%). As a primary goal of the course, no (100%).

10. *Question.* Is the tremendous impact of physical science upon our culture a proper subject to be presented by a physicist?

Answer. No (100%), except that 5 percent of the colleges give courses in the history of physical science which are probably appropriate to this goal.

11. *Question.* Should courses be offered directly analyzing the methods of investigation used in physics?

Answer. Yes (10%). Another 10 percent give some course in which it is apparent that method of investigation is of primary concern and subject matter content is secondary.

From this survey I find that we are unanimous in the opinion that our main business is to train professional physicists. Our physics curricula are vertical: they are educational totem poles on which the arts and premedical students are the low men. Our horizontal extension is very limited. Perhaps it isn't physics, but the physicist has much in knowledge and understanding which would be valuable to students whose goal is not that of physics as a profession. We are doing little to make these available to such students.

Limitations of staff and facilities will make it impossible for most of us to do both. At present we are all doing the one thing, the vertical curriculum, and largely omitting the horizontal one. In looking at the great array of courses which we have set up for the training of professional physicists I am led to question whether the results are worth the cost. The cost in facilities and instruction time is large and the output small. Perhaps we would do a better job for our students and for physical science if we devoted a smaller part of our resources to producing physicists.

Here is a concrete proposal. The college I know best now offers 36 credit hours in the vertical sequence. Of these, 26 have calculus as a prerequisite. Why not cut this to 18 hours total made up of a first course of 12 hours with

calculus as a corequisite and an advanced course of 6 hours? This much with a strong supporting program can be completed by the student in his junior year. If he is one of those rare students whose interests and abilities point toward a career in physics he can transfer to a large college or university for his senior year. If circumstances prevent this he can still meet the minimum requirement for an "earn while you learn" program by finishing at his own school. The mathematics department gives a course in theoretical mechanics which is perfectly good physics. All that will be necessary will be to give this course a number in the physics department—double numbering is legal—and our student can have the 24 hours of physics credit needed for a civil service or other similar appointment.

In advocating this program of parsimony in training of physicists I do not have in mind de-emphasis of physics in the arts college but rather the expansion of the physics program. By this cut we have picked up 9 hours of teaching load per semester for doing other things. Physics is basic to every phase of life and we can use the time gained for enlarging the number of students that will include physics in their educational experience.

Later I shall have some more specific recommendations to make as to things that ought to be done with part of this instructional time but part of it, I urge, should be according to special interests of the instructor. The courses of this group should avoid any attempt to be respectable. The only prerequisite might be ability to read and write English. I think the courses should not be open to freshmen, as they should be mature in approach. Here is a list of such courses as occur to me. With them I have listed parenthetically the groups of students to whom they might appeal.

Music (musicians and tone-deaf music lovers)
Science Fiction (students of creative writing, psychology, and philosophy)
Color (artists, also women and most men)
Gadgets of Home and Office (students of home economics and any who expect to own or operate a home)
History of Physics or Philosophy of Physics (students of philosophy, of history, or anyone who likes civilization better than the other thing)
Manufacturing Processes (economics, and business administration majors)
Atomic Energy and Its Control (students of economics and political science and those who think survival is a good idea)
Generation and Use of Electric Power (students of economics and business administration)

The extent of this list is limited only by the imagination. The courses are not so worthy in themselves but will be profitable for the student if they are profitable for the professor. None of these is a must. Pick yourself one of wide appeal which would be fun for you.

There are other courses which are urgently needed. These are courses for training high school teachers of physics, for premedical education, and for application of physics to other sciences.

In Ohio, the training of high school physics teachers must become a matter of concern to us as individuals and as a professional group. We need to secure an increase in the requirements for the certification of teachers of physics so that they are equal to those for such fields as home economics, speech, and physical education. Since women are a majority among the high school teachers we need, for selfish reasons if for no other, to break down the prejudice against women as teachers of physics. As individuals we ought to find out more about the job of the high school teacher. Most of us are "old-fogey" in our ideas of secondary education. If we can get over this and approach the job realistically we ought to offer a course in teaching methods. If we cannot get rid of old prejudices sufficiently to create enthusiasm in the prospective teachers, we can at least give a course in making and contriving apparatus.

Pre-medical physics is in a worse state. Though the present day physician has more and more call to be a physicist in both the spirit of his approach and the equipment that he uses, the premedical physics remains feeble. Medical schools are shifting their administrative application of the "8 hours of physics" requirement to a perfunctory acceptance of whatever is offered. Students look upon the requirement as a foolish nuisance. From our catalogues it appears that this attitude is only a reflection of our own. Very few of us give any course which is calculated to have direct appeal to the pre-medical student. It is all very well to say that what the pre-medical student needs is straight physics but this does not solve the problem. I know you can quote a distinguished alumnus (physician) who says, "I didn't see it at the time, but I've been thankful you made me learn my physics." But what the student is going to say 15 years hence has little effect on his present attitude. There are text books and published reports to serve as a guide for any of us who wish to tackle the job. The point I want to make is simply that it is our job to so present physics to the premedical student that he sees its value and is interested. A few docile souls will study industriously on the assurance of some authority that they will later find value in what they are learning. The men who will become the medical scientists of the future are not of this frame of mind. If they can be really interested they may take more than the minimum of 8 hours of physics with us.

Akin to this problem of physics in relation to medicine is that of the other sciences. Not many years ago it was not uncommon for a student to complete a major in chemistry with little or no physics. That condition still exists in some schools, largely due to departmental rivalry. It has now come to be recognized that the chemistry major needs strong supporting courses in mathematics and physics. Improvement in the physics-for-chemists program can frequently be made if the physicist will go to the chemistry department with the simple question—what does the chemist want? The development of physics-for-biologists, physics-for-geologists, and physics-for-psychologists is at a much more elementary stage. It is an observable fact that a student's prospects of achievement in these fields are greatly enhanced by supporting study of physics. Mere requirement of physics for a major in those fields will accomplish little. We need to so contrive our choices of subject matter and method that the students will recognize the values in the physics department and elect our courses.

In conclusion, let me draw attention away from details to the one proposition, that we, as physicists, have a broad field of studies to occupy. I am not arguing for putting in required physics but rather for so exploring the interests and needs of students that they may be led to elect to study with us for a time. If this seems beneath the dignity of a physicist, I suggest a rereading of the life of Galileo.

THE UNDERGRADUATE PHYSICS CURRICULUM IN THE ENGINEERING COLLEGE

DUDLEY WILLIAMS

Department of Physics, The Ohio State University, Columbus 10

As the details of the physics curriculum vary widely in the various engineering colleges throughout the country, this paper will be restricted to only two phases of the engineering physics curriculum. The first part of the paper deals with general trends in the development of introductory physics courses in various engineering colleges. The second part of the paper gives a brief description of

the physics courses offered in Engineering Physics Curriculum at The Ohio State University. No attempt to give a complete survey of engineering physics curricula is made.

In surveying the introductory physics courses offered at various institutions, one observes three major trends. The first of these involves the devotion of more time to the introductory courses. For many years, Massachusetts Institute of Technology has offered a two year course in general physics. This has also been customary in many of the Canadian universities. Vanderbilt University has recently adopted a course of this type. At the Ohio State University, the engineering physics students take an introductory physics course equivalent to approximately one and two-thirds years (24 quarter hours) of the conventional one year 5-hour course. Institutions now offering a 3-semester course in introductory physics include Carnegie Tech and Northwestern University. An 18-quarter hour course is offered at the Georgia Institute of Technology.

A second trend lies in the tendency toward a more mathematical treatment of the subject. In the MIT course the calculus has long been used from the

TABLE 1

	Autumn	Winter	Spring
Second Year (Introductory Physics)	Mechanics (5) E. and M. (4)	Heat, Sound, Light (5) E. and M. (5)	E. & M. (4)
Third Year	Geom. Optics (3)	Physical Optics (3)	"600" Elective (3)
Fourth Year	Heat and Thermodynamics (3) Intermediate Mechanics (3) "600" or "700" Elective (3)	Wave Motion and Sound (3) Intro. Quantum Mechanics (3) "600" or "700" Elective (3)	Kinetic Theory (3) "600" or "700" Elective (3)
Fifth Year	Nuclear Physics (3) X-rays (3)	Atomic Spectra (3) Elective (3)	Molecular Spectra (3) Elective (3)

beginning. Now that introductory calculus courses are being offered in the Freshman year in many institutions, other physics departments are able to employ the calculus earlier than had hitherto been possible. At Ohio State the engineering students have a brief introduction to the differential and integral calculus during their first year at the University. In the physics course, which comes during the second year, the use of the calculus is introduced gradually in order to permit the student to "catch his breath" before applying his newly acquired mathematical skills. However, many of the brighter students are somewhat impatient with this delay and would prefer to make full use of their mathematics from the outset; some of the staff members prefer to delay full employment of the calculus in the thought that its too early use tends to divert the student's attention from the basic physical principles that form the core of the course.

The third trend in the introductory courses lies in the employment of the MKS system of International Metric Units so long advocated by the electrical engineers. Toward this change many physics instructors have been lukewarm if not openly hostile. However, there is strong pressure, originally from the engineers and now from physicists themselves, to adopt this system—with the electrical units in their so-called "rationalized" form. The writer's experience in teaching a course in which these units are employed indicates that considerable time is saved by defining the *joule* and *watt* from the outset instead of first defining the

erg and *erg/sec* and then stating the "practical" work and power units as multiples as has been customary in the past. The advantage of the MKS system in introducing the electrical units is, of course, obvious. However, it does come as a shock to one brought up on the CGS system to see Planck's constant given in *joule seconds* and to express *e/m* in *coulombs/kilogram!*

As for the Engineering Physics Curriculum at the Ohio State University, it should be pointed out that *the engineering program of study is now a five-year program.* The engineering physics student takes no physics during his first year. During the subsequent years the program of physics courses with quarter hours of credit is given in table 1.

The "600" electives may include the following courses: Design and Theory of Optical Instruments, Advanced Electricity, Conduction of Electricity through Gases, Thermionics, Electromagnetic Field Theory, Introductory Nuclear Physics, Advanced Laboratory Work, Experimental Infrared Spectroscopy, Nucleonic Instrumentation, and Physical Meteorology. The "700" electives include: Minor Problems in Physics (an individual "special project"), Methods of Quantum Mechanics, and Introduction to Theoretical Physics.

As far as course work is concerned, the program given above, together with supporting courses in mathematics, chemistry, engineering, and "non-technical" courses in social sciences and humanities is equivalent to the course work taken by graduate students taking the M. S. degree—except for the fact that a thesis is not required. By doing additional work in the last two years and by writing a thesis, the superior student can actually receive a master's degree at the same time he receives his B. S. degree in Engineering Physics.

THE UNDERGRADUATE CURRICULUM IN PHYSICS FROM THE POINT OF VIEW OF INDUSTRY

J. F. EICHELBERGER

Mound Laboratory,[1] *Monsanto Chemical Company, Miamisburg, Ohio*

In this paper, I shall attempt to examine the adequacy of the undergraduate curriculum to prepare the possessor of a Bachelor's degree in physics for a position in industrial research. Since the industrial laboratory is one of the main consumers of the universities' and colleges' product, graduates, it is obvious that our voice should be heard in a symposium such as this.

I hope that the suggestions that are to be offered are practical, in the sense that they can be accomplished without requiring major expenditures of money. If the suggestions are followed, I believe that graduates produced under this system should be of more immediate use and have a potentially greater future.

In doing research, one generally makes a literature survey first and proceeds to utilize the best of the most pertinent information. In constructing this paper, I preferred to start by assembling all my own ideas and prejudices which are based primarily on having read many applications for jobs, having interviewed a selected number of applicants, having hired those who were judged desirable, and in subsequent years evaluating these men's work for merit raises or promotions. My opinions have been influenced to some extent by the sharing of experiences

[1]Operated by the Monsanto Chemical Company, under AEC Contract Number AT-33-1-GEN-53.

with other physicists and chemists with the same general experience. After I had set down my own thoughts, I then went to the literature to judge if I had strayed too far from the opinions of others. I was prepared to take a large divergence in opinion as evidence that I was "off the beam," a moderate divergence as encouragement that perhaps I had something to contribute, and zero divergence as evidence that I had nothing new and was wasting your time. I would be wasting your time because all the remarks were in the literature. You had heard or read the ideas before and done nothing to put them into effect, and therefore I could assume that not much good would come of presenting again the same material.

So here is the plan of attack. I shall review the organization of a laboratory so that you may see where the man with a Bachelor of Science in physics fits. I shall discuss the method of hiring, the first job, the possible promotions, and certain possible fields of specialization. I shall then set up the general deficiencies of the undergraduate curriculum in terms of a comparison of the average training with a desirable training; and I shall make this discussion in terms of the training of the university or the college with respect to what a man needs for his first job and what he needs for the long run. After these remarks have been made, I shall attempt to suggest what can be done to realize some of the suggestions.

A large research laboratory will have an organization much like the following:

1. A director who has a secretarial staff, an assistant director, department heads, the plant physician, and the plant accountant reporting directly to him.
2. Department heads who have a number of section heads reporting to them.
3. Section heads who have a number of group leaders, supervisors, or foremen reporting to them.
4. The group leaders, supervisors, or foremen who have the scientists, technicians, office staff, and skilled and unskilled laborers reporting to them.

In some laboratories all the nontechnical functions are under the supervision of one man, the business manager, who reports directly to the laboratory director; and in other laboratories, the nontechnical functions are organized into several departments, each of whose department head reports directly to the laboratory director. Figure 1 gives an idea of a typical organization.

A group or project in research will consist of some four to seven men working on several closely allied problems. The supervisor of the group is responsible for a number of administrative duties. A group will contain one or two Ph. D's and the rest Bachelor's or Master's. In development work or pilot plant work, groups may be much larger with practically all of the men at the M.S., B.S., and technician levels.

The Bachelor of Science or Arts in physics will be classed as a technical trainee in his first job. At the end of his first year, he will be promoted to the rank of assistant physicist if he has demonstrated that he has adapted himself to the company's policies and if he shows evidence of being able to advance in ability. During that first year, the young physicist will have found that he has difficulty in applying what he was taught, that he has been dependent on the more mature men, that the reports he wrote have been unsatisfactory, that the laboratory has local experimental techniques that are unfamiliar, that he doesn't know enough about the literature of mathematics and physics, and that he is deficient in laboratory skill. After the first year, he will probably progress steadily, earning merit raises; and in about six years he will be promoted to the rank of physicist. After another six to eight years, he will again be ready for promotion. At this stage, if he is well above average, he will probably have assumed some administrative responsibilities and will be directing his career towards administration. If he is average or below average, the physicist with a Bachelor's may be nearing the top of his career.

Each year when the scientist is considered for a merit raise, the supervisor will have to answer a number of questions such as:

1. Has the scientist's research ability increased during the year?
2. Has he shown cost consciousness?
3. Has he gotten along well with his fellow employees and supervisor?
4. Does he show signs of developing into a leader?

Now let us examine the hiring of an inexperienced owner of a Bachelor's Degree. He will fill out an application blank and submit it by mail or he will show up in person at the laboratory to fill out the questionnaire. If the laboratory is interested, an interview is conducted to assess the applicant's training, ability, and personality. A rough rule has evolved in estimating the relative training of applicants: prefer a B.S. in Engineering to a B.A., prefer a graduate of a university to a graduate of a college.

These preferences result from the fact that the B.S. in Engineering from a large university will have had about 160 or more semester-hours compared to 120 or more semester-hours for the B.A. from a college. The B.S. in Engineering will have had more physics, far more laboratory work, more mathematics, and some useful engineering. One of the important problems to be discussed then is: What can be done by the colleges to improve the position of their graduates? The obvious answer is to see that their students take about 20 credit hours or more per semester. These extra hours should preferably go into physics, mathematics, and laboratory work. If this isn't possible, the extra time could go into chemistry, geology, biology, German, and French. Particularly a greater knowledge of chemistry, the ability to read scientific German and French, and the ability to write good technical reports would improve the immediate usefulness to industry of the graduate from a college without large laboratory facilities.

However, I believe the small college can offer more in the physics and mathematics departments. In the previous paragraph, I suggested increasing the credit hours by roughly 25 percent. To put this suggestion into effect would require either a 25 percent increase in teaching load or additions to the staff with increases in student fees. Personally, I would suggest the increase in teaching load insofar as it is humanly possible. This increase in teaching load could and should be considerably alleviated by the students helping the faculty—paying the increase in fees by working for the college.

We saw previously that the physicist in industry will work in a group under an older, more experienced supervisor. We learned that his advancement will be based on his increase in ability, cost consciousness, ability to get along with people, and development of leadership. The students can acquire in college some of this general philosophy of group work if they are regularly assigned to some faculty member to help him in his work. Let us suppose that each faculty member had two seniors, two juniors, and two or three sophomores as his responsibility and that each student spent two afternoons a week or the equivalent at the laboratory repairing apparatus, taking inventory, setting up equipment for demonstration lectures or sophomore laboratory, helping in sophomore laboratory, grading problems or laboratory reports, typing, tutoring, helping the staff in their research, . . . , essentially anything that reduces the load on the faculty to compensate for the increased teaching load. A system in which the faculty tutored the seniors and graded their papers and reports, the seniors tutored the juniors and graded their papers and reports, the juniors acted in the same capacity with respect to the sophomores, and the sophomores helped in freshman mathematics or chemistry would create an atmosphere somewhat like that of the industrial laboratory: responsibility, consultation, promotion, authority, and interplay of personality.

Ordinarily a few of the students earn some money by work of this nature. However, I believe all the students should work, just for the value of learning how to work. The closer association with members of the faculty and fellow students should stimulate interest in physics. The interest in physics should be further

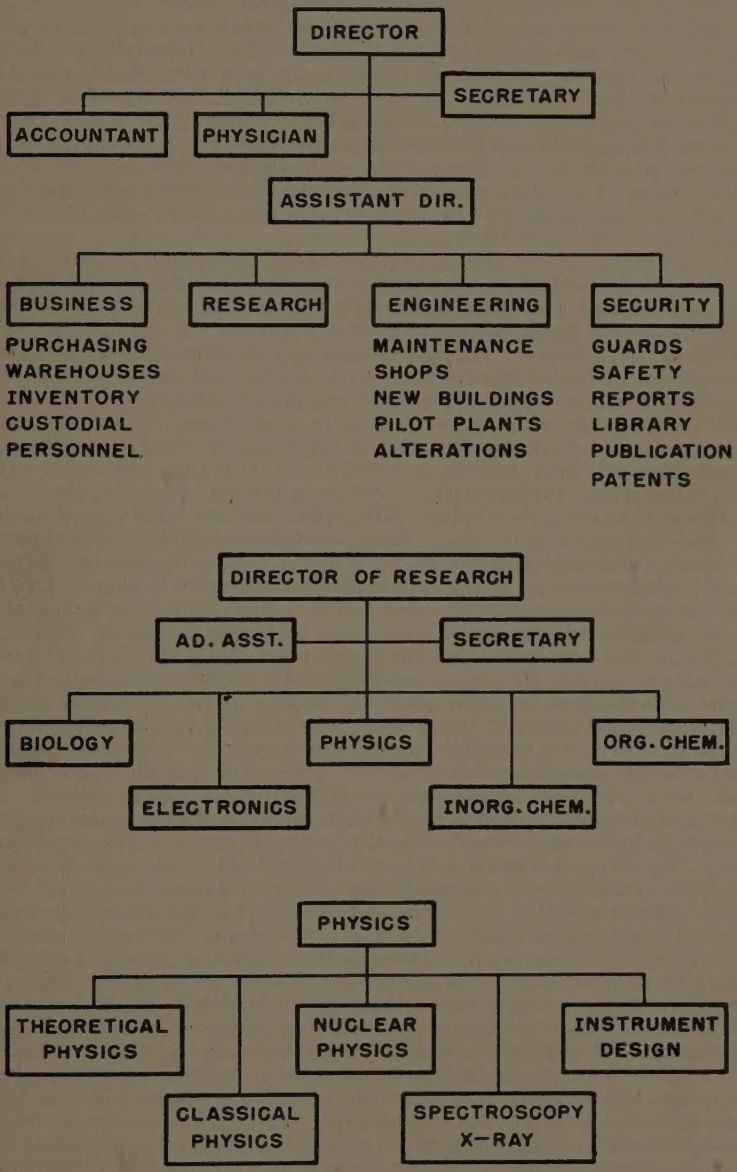


FIGURE 1. Typical organization chart of large research laboratory.

stimulated by requiring that the students spend two or three afternoons in the laboratory on their own problems. By requiring the student to spend so much of his time with the physics department in work, study, and experiment, physics and the laboratory become the focal point of his existence, a desirable psychological condition. In addition, these many hours in the laboratory should remedy the rather alarming lack of laboratory experience too often observed in the graduate from the smaller schools. As part of this process of making physics important to the student, I believe that the students should be allowed and encouraged to come back to the laboratory at night to study. The physics library should be in the same building and open for use. The students should have space available to them, a room with desks or tables and blackboards. Here again, group study and discussions would be stimulated.

The importance of laboratory training has already been indicated. There are several things I would like to suggest as potentially valuable to the student. The students should work part of the time in pairs and part time individually. The student and the faculty should be given the opportunity to judge the student's individual ability, initiative, and self-reliance and his group ability, cooperation, and leadership. The laboratory work in the junior and senior year should be sufficiently involved to require more than one session to complete. The student should be required to write a good report in conformance with some standard form. The quality of the report should be evaluated separately from the quality of the experimental work, since it is entirely likely that they will not be of equal quality. The report should contain a list of references, since the student must get in the habit of using the library. The report should contain a good discussion of the probable error of the result, distinguishing between the random errors of observation, the probable errors of the physical constants, and the systematic errors of the instruments. It would be of considerable value to require the student to look up in the manufacturer's catalogs the cost of the instruments that were used, to estimate the number of man-hours that were consumed in doing the experiment, and to estimate any additional costs involved in the experiment. This attention to cost will give the student some experience in estimating how long and how much money it takes to do things. It will also make him learn a little about what types of instruments are available commercially and from what companies. It is desirable in connection with the laboratory work that the student learn something about machine tools. The mention of machine tools reminds me of two more habits that can be cultivated while at school. These habits are: conformance to safety rules and the practice of good housekeeping.

I want to digress momentarily and then say a few more words about the laboratory. There is often discussion as to what percent of a college curriculum should be devoted to establishing a cultural background so that the graduate will be well-rounded. My prescription is that the student should take a maximum of mathematics, physics, and chemistry at the expense of the cultural courses. This opinion is based on economics and common sense. The man with the best technical training will get a job more easily and progress faster. It is easier to learn science in school and acquire culture later outside of school than it is to acquire culture in school and to learn science later outside of school. Cultural and business courses are usually more available in night schools than technical courses.

I don't want to give the impression that the scientist shouldn't be prepared to enjoy life, but I believe that the student can be given some background for cultural growth directly through his science. Hobbies can be used as an outlet for a man's desire to build, to tinker, to collect, to classify, and to express himself artistically. Since hobbies are seldom unique, they provide social contacts with other enthusiasts in the same field. A few hobbies can be enjoyed by the physicist's entire family—don't let the sudden appearance of this family startle you. In their quiet ways, physicists are accustomed to accomplishing wonders. These hobbies that I am gradually getting around to mentioning involve techniques

and knowledges such that part of the laboratory time could be devoted to establishing one or two of them. I have in mind such things as audio amplifiers, photography, metal or wood working, gem grinding and polishing, mirror making and astronomy, and amateur radio. I am particularly inclined to recommend audio amplifiers, as this hobby generally leads to the collection of phonograph records and a great interest in classical music, jazz, or both. The interest in music is then particularly valuable because the entire family will become interested. I don't know how far your colleges and universities would go in sponsoring another kind of study, but frankly when you get into industry the following kind of training for the industrial physicist is often very valuable—very. I refer to class-room lectures on choice and chance and on the theory of games and to laboratory work in applying the principles to craps and poker. I am sure the faculty would be amazed by the willingness of the students to attend long late evening classes in this course and by their zest in conducting experiments.

Let us talk now about the lectures and class-room work. I want first to take up two courses that the physics student usually writes off as a waste of time. If he has to take them, they will amount to about 10 percent of his total credits—8 semester-hours of physical education and 8 of military. Let us consider military study first. In these years, it appears inevitable that this study will be necessary. It appears probable that the physics graduate will go into either civilian or military work in which he uses his training in physics. So instead of the usual military training, why not give a course in which the physical principles of weapons are studied? This is only applied physics and would supply the physicist with a useful background for war research or specialized service in the armed forces. To give a few examples, the student could be shown how the principles he has learned in his regular classes have been used to develop and study radar, sonar, loran, jets, ram jets, telemetering, gyros, internal and external ballistics, snooperscopes, shaped charges, chain reactions—the list is long. Many branches of mathematics, physics, and chemistry have found practical use in military weapons.

While the suggestion of the study of physics of weapons has an unpleasant aspect, I believe that today it is a practical suggestion. I believe the student and the nation stand to gain by a study of the physics of weapons rather than the conventional military training. The other course, physical education, can also be given a rather practical slant, but this time much more pleasant. When the physicist accepts a job in industry, he will probably find a great deal of interest in sports. There will be teams and leagues engaging in bowling, golf, softball, basketball, tennis, and ping pong. Participation in one or more of these sports has a good deal of value in increasing a man's ability to get along with his fellow workers. Participation also increases the social horizons because of the chance to meet people informally. A study and practice of these games would provide the necessary exercise while in college and provide a training for continued exercise after leaving college. In coeducational schools, it might be possible to teach folk dancing as a substitute for physical education. From what I've seen, there is plenty of sweat in folk dancing, if this is a measure of value. Of course, the true value of folk dancing lies in the fact that in later years it provides exercise and promotes a community atmosphere.

Let us turn now to the discussion of the class-room work. I want to begin by restating my belief that 160 or more semester-hours is desirable. Forty or more hours of this total ought to be devoted to mathematics, 50 or more hours to physics, and 15 to 20 hours to chemistry. In mathematics, I suggest 10 semester-hours of the freshman year should be devoted to algebra, trigonometry, and plane and solid analytical geometry; 10 hours of the sophomore year devoted to differential and integral calculus including double and triple integrals; 16 hours of the junior year spent on four courses, advanced calculus and the theory of equations in the first semester and differential equations and numerical methods in mathematics (Scarborough) in the second semester; 8 hours of the senior year should be allotted

to a course by some name such as "Mathematics for Engineers" or "Applied Mathematics" corresponding to texts such as Reddick and Miller or Burrington and Torrance. This program in mathematics will probably draw some disapproval because of the 8 hours of mathematics per semester in the junior year. All I can say is that it is still a compromise with my real hope and belief. I would really like to see 10 semester-hours of mathematics in the first half of the freshman year devoted to algebra, trigonometry, and analytical geometry; and 10 hours of the second semester spent on differential and integral calculus; 5 semester-hours of the sophomore year on advanced calculus and 5 semester-hours on differential equations; mathematics for engineers the junior year (Fourier series, Bessel functions, vector analysis, complex numbers, operational calculus, elliptic integrals, . . .); theory of equations and numerical methods the senior year. While such a program is very heavy the freshman year, I believe that any student that couldn't handle it wouldn't make a good physicist anyway. This program would be hard on the mathematics department, but you physics teachers ought to regard how nice it would be to teach sophomore physics to students that had finished calculus and to teach advanced undergraduate physics courses to students that had finished advanced calculus and differential equations. Is that 20 credit hours of mathematics the freshman year any more difficult than 10 hours of physics and 10 hours of calculus in the conventional sophomore year? The two programs may be compared by referring to Curriculum I and Curriculum II at the end of the paper.

Let us look at a minimum physics curriculum now. General physics with three or four hours of laboratory would be taken in the sophomore year. The student would take 4 hours of heat and thermodynamics in the first half of the junior year and 4 hours of light and optics the second half. In the senior year he would take 5 hours of mechanics and 5 hours of electricity and magnetism the first semester; and in the second semester he would take 5 hours of modern physics and 5 hours of atomic physics. As I mentioned earlier, the student would spend 4 or 5 afternoons in the laboratory on his own work and helping the faculty.

General chemistry and laboratory would be taught the freshmen year and one semester of physical chemistry with laboratory would be taught the junior year. These basic courses in the sciences should be extended in the junior and senior year by allowing the physics students that get suitable grades to take an elective of three hours each semester.

The rest of the curriculum would be devoted essentially to cultural subjects; but even here I would give many of them a technical flavor. The freshman year would be completed by the following semester hours: two in engineering drawing with most of the emphasis on sketching, six on English grammar and the technical report, three on economics, and three on business administration and research administration. The sophomore year would be completed by a 4-hour survey course of the various branches of modern chemistry and of the chemical industry, 3 hours of geology, 3 hours of mineralogy, and 4 hours of abnormal psychology or sociology to teach the student something about the human mind and human nature. The junior year would include 3 credit-hours of astronomy; and the senior year would include 4 semester-hours of the history of mathematics and physics.

I prefer to make no suggestions about electives, as I believe that they are best handled by allowing a group of students to ask a faculty member to teach a mutually acceptable course.

The physics staff ought to furnish the student a number of noncredit services: a journal club or seminars, instruction as to the standard journals and books in physics and mathematics, and several talks on orientation. Orientation should acquaint the seniors with the names, locations, and purposes of industrial laboratories, government laboratories, and research foundations. The seniors should be informed qualitatively with respect to wage scales, pension plans, group insur-

ance, health insurance, and working rules and conditions. The student should be given hints on how to conduct himself during an interview. He should be taught how to write a letter of application for a job and should be instructed to enclose a transcript of his record. The chairman of the department should keep a file on each student compiled from the opinions of the department members with respect to the student's classroom and laboratory ability, research attitude, initiative, cooperativeness, leadership, and other personal characteristics. An accurate letter of appraisal of a student's college record by his teachers is very important in obtaining the first job.

There are a few specialized jobs in the laboratory for which a student might modify the suggested course. Students interested in becoming administrative assistants to research directors might sacrifice some of the suggested courses in order to take accounting, business, and management courses. Students interested in becoming a technical editor would want to study more English and probably ought to attempt to learn more chemistry and some biology. Students interested in library work would of course want some library science, a reading knowledge of German and French, and some knowledge of biology. Students interested in instrument design should take much more training in engineering drawing and some courses in mechanical engineering such as kinematics of machinery and machine design.

In teaching the physics and mathematics courses, I believe the students get the most value from final examinations consisting of reasonably difficult problems to be done during the last two weeks to a month, using any text or journal for reference. This nicely approximates writing a report to meet a dead-line in an industrial laboratory.

If this proposed curriculum is as successful as I hope in imbuing the student with an interest in physics and with the research attitude, I am afraid the student will decide to go to graduate school. I have one consolation, the faculty that successfully administers a program calling for such close association between faculty and students will find that the teachers are playing the roles of group leaders in industrial laboratories. Those faculty members that find this system agreeable can step right into the industrial laboratory. So perhaps if industry loses the well-trained students to graduate school, industry may console itself by hiring the well-trained faculty.

Curriculum I

Mathematics essentially concurrent with physics

FRESHMAN

	Credit Hours		Credit Hours
General Chemistry	6	General Chemistry	6
Algebra and Trigonometry	5	Analytical Geometry	5
Technical Composition	3	Technical Composition	3
Economics	3	Business and Research Admin.	3
Engineering Drawing	1	Sketching	1
Physical Education	1	Physical Education	1
Military	1	Military	1

Two afternoons in chemistry laboratory and one in drawing

SOPHOMORE

Calculus	5	Calculus	5
General physics	6	General Physics	6
Geology	3	Mineralogy	3
Abnormal Psychology	2	Abnormal Psychology	2
Survey of Modern Chemistry	2	Survey of Industrial Chemistry	2
Physical Education	1	Physical Education	1
Military	1	Military	1

Two afternoons in general-physics laboratory, other afternoons spent in helping faculty and in study laboratory.

CURRICULUM I—*Continued*

JUNIOR

	Credit Hours		Credit Hours
Theory of Equations	4	Differential Equations	4
Advanced Calculus	4	Numerical Methods	4
Thermodynamics	4	Light	4
Astronomy	3	Physical Chemistry and Lab.	4
Elective	3	Elective	3
Physics Laboratory	3	Physics Laboratory	2
Physical Education	1	Physical Education	1
Military	1	Military	1

Afternoons spent in laboratory on own work or helping faculty.

SENIOR

Mathematics for Engineers	4	Mathematics for Engineers	4
Physical Mechanics	5	Modern Physics	5
Electricity and Magnetism	5	Nuclear Physics	5
History of Physics and Math.	2	History of Physics and Math.	2
Elective	3	Elective	3
Physics Laboratory	2	Physics Laboratory	2
Physical Education	1	Physical Education	1
Military	1	Military	1

Afternoons spent in laboratory on own work and helping faculty.

CURRICULUM II

Mathematics essentially one year ahead of physics

FRESHMAN

	Credit Hours		Credit Hours
Algebra, Trigonometry, and Analytical Geometry	10	Calculus	10
General Chemistry	6	General Chemistry	6
Abnormal Psychology	2	Abnormal Psychology	2
Physical Education	1	Physical Education	1
Military	1	Military	1

SOPHOMORE

Advanced Calculus	5	Differential Equations	5
General Physics	6	General Physics	6
Engineering Drawing	1	Sketching	1
Geology	3	Mineralogy	3
Technical Composition	3	Technical Composition	3
Physical Education	1	Physical Education	1
Military	1	Military	1

JUNIOR

Mathematics for Engineers	5	Mathematics for Engineers	5
Thermodynamics	5	Kinetic Theory	4
Astronomy	3	Physical Chemistry and Lab.	4
Geometrical Optics	2	Physical Optics	3
Physics Laboratory	3	Physics Laboratory	2
Physical Education	1	Physical Education	1
Military	1	Military	1
Elective	3	Elective	3

SENIOR

Theory of Equations	4	Numerical Methods	4
Physical Mechanics	5	Modern Physics	5
Electricity and Magnetism	5	Nuclear Physics	5
History of Physics and Math.	2	History of Physics and Math.	2
Physics Laboratory	2	Physics Laboratory	2
Physical Education	1	Physical Education	1
Military	1	Military	1
Elective	3	Elective	3

ADAPTATION OF AN X-RAY TUBE FOR TAKING ELECTRON DIFFRACTION PHOTOGRAPHS

KARL A. DAVIS AND JOHN E. EDWARDS
Department of Physics, Ohio University, Athens, Ohio

An x-ray tube having removable target and filament assemblies normally requires considerable auxiliary equipment which is more or less permanently attached to the tube. Such equipment includes an evacuating system, a vacuum gauge, liquid coolant, and a high voltage source. In general, the same type of equipment is required to operate an electron diffraction unit.

In view of this, a demountable x-ray tube in this laboratory was modified to function either as an x-ray tube or as an electron diffraction tube depending upon the attachment of either an x-ray target or an electron diffraction camera.

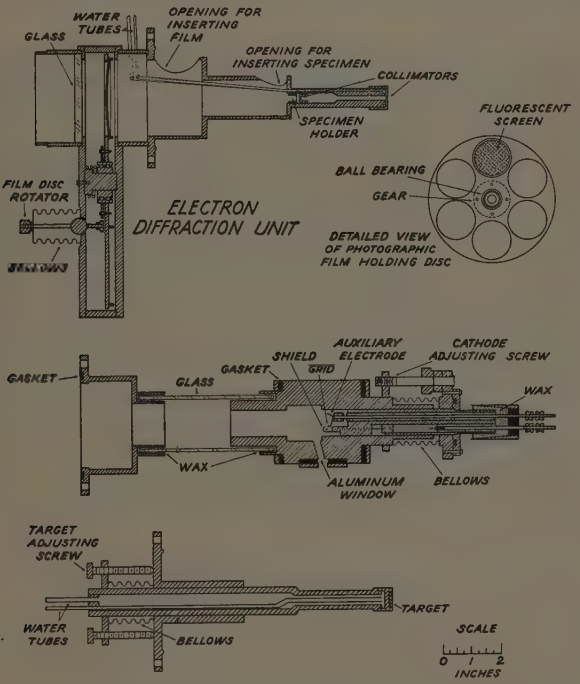


FIGURE 1. Sectional drawing of the combination tube.

THE DUAL PURPOSE TUBE

The basic x-ray tube before modification was designed by Dershem (1936) for use in vacuum spectrographs. The filament assembly and the copper shield surrounding the target and the filament were not changed. The target assembly and the target end of the tube were altered to accommodate the electron diffraction camera.

The drawing at the top of figure 1 shows a sectional view of the electron diffraction assembly which was designed to be inserted into the position normally occupied

by the target assembly. The center drawing is a sectional view of the x-ray tube with the target assembly removed. The x-ray target assembly is represented in the lower drawing. The portion of the electron diffraction camera which includes the anode, collimators, and specimen holder, resembles the x-ray target. A brass cap soldered to the end of the hollow stem is pierced in the center by a 0.0135 inch hole which serves as the first collimator for the electron beam. The hollow stem also carries the second collimator and the specimen holder which are easily removed. The second collimator has a diameter of 0.006 inches. The specimen holder and second collimator are adjustable longitudinally. Several by-pass openings in the sample holder prevent breakage of the thin sample during evacuation of the system. Electrons leaving the sample travel a distance of seven inches to the film where a diffraction pattern of maximum diameter 3¼ inches may be formed. The film holding disc holds five films and the fluorescent screen. The disc is held against the front of the camera case by a coil spring but it is easily rotated without disturbing the vacuum. The rotation is accomplished by engaging the larger gear on the disc with a small gear attached to the flexible bellows. By

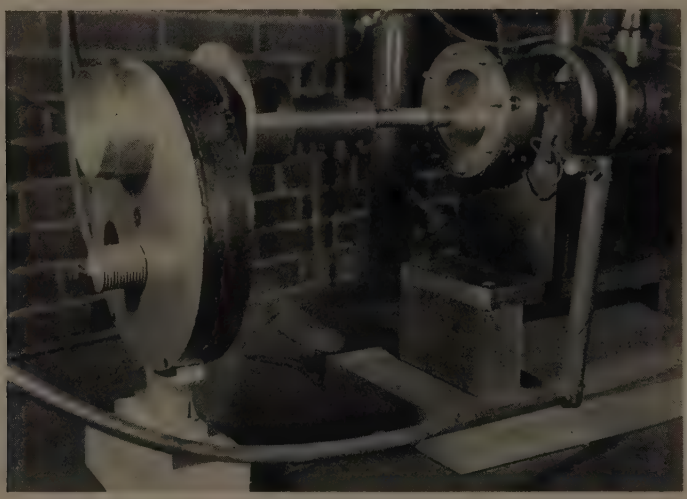


FIGURE 2. Rear view of the electron diffraction camera.

moving the rotator a short distance and re-engaging the gears, a new film can be brought into exposure position. When the fluorescent screen is in exposure position the camera is light tight for the five films, but the fluorescent screen viewing tube is covered by a cap to prevent fogging when a film is moved into position. The films are held in the cells on the disc by springs. Only one rubber ring vacuum seal is involved in converting the tube from x-ray to electron diffraction work. Figure 2 shows a rear view of the camera.

A focused electron beam is supplied by a filament and grid assembly. The electrons are deflected from behind a molybdenum shield by a positive voltage on the grid and auxiliary electrode. They can then come under the influence of the high voltage field. Sharpness of the focus at the first collimator is controlled by adjusting the distance of the cathode assembly from the target. The position of the focal spot can be swept back and forth over the central region of the first collimator by varying the grid voltage. A maximum supply of electrons can thus be obtained by varying the grid voltage and watching the brilliance of the pattern on the fluorescent screen. Grid voltages vary from 50 to 300 volts and are furnished

by a small direct current power source. A generous supply of electrons for diffraction photographs can be obtained with target currents less than 0.5 milliamperes.

Voltages as high as 50 kv are supplied to the tube by a full wave rectified source using filter condensers of 0.4 microfarads capacity. The tube is evacuated with a two-stage oil diffusion pump and is frequently operated with the diffraction camera without use of a cold trap on the pump.

PROCEDURE

The tube is being used for instructional purposes in the advanced physics laboratory. A series of five transmission type electron diffraction photographs taken at various voltages can be secured during a two to four hour laboratory period. Samples of gold and silver have been used but the most consistently good results are obtained with MgO. All of the samples are deposited on thin collodion. The collodion film is prepared by dropping a small amount of a collodion-amyl acetate solution on water. After evaporation of the amyl acetate the sample holder is slipped under the film and lifted up slowly, then allowed to dry. Gold or silver may be sputtered on the collodion film but a most satisfactory sample for instructional purposes can be prepared quickly by holding the sample holder in the "smoke" stream about eight inches above a burning magnesium ribbon.

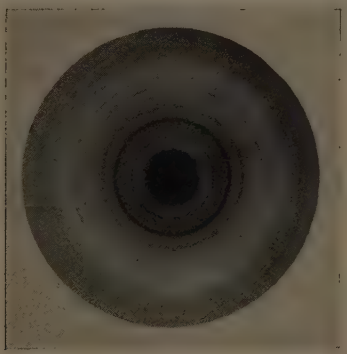


FIGURE 3. Electron diffraction pattern of MgO taken at 26 kv.

After inserting the sample and films in the camera, it is bolted into position and the system evacuated. The diffraction pattern is first checked with the fluorescent screen, then the high voltage is removed, the grid voltage is reversed, and a film is moved into exposure position. The grid provides a very convenient method for making exposures. It is biased negatively to deflect the electron beam from the collimator until the high voltage builds up to a pre-set value. Then the grid is made positive for the desired exposure time. Satisfactory photographs can be obtained with exposure time as low as 0.5 sec. Figure 3 shows a diffraction pattern of MgO taken at 26 kv. The central region of the pattern was over-exposed in printing the photograph to show several circles on one print.

The focusing requirements in securing an adequate supply of electrons are not severe. A central spot can be seen on the fluorescent screen when the tube is operated without grid or filament shield. It is believed that many types of demountable x-ray tubes might be adapted for electron diffraction work. Where more space is available at the target end of the tube provision might easily be made for manipulation of the sample.

LITERATURE CITED

Dershem, E. 1936. A shielded filament x-ray tube for pure x-ray spectra. Rev. Sci. Instr., 7: 86–89.

A SIMPLE PALEOBOTANICAL TRANSFER TECHNIQUE

RALPH E. ABBOTT AND MAXINE L. ABBOTT

Departments of Geology and Botany, University of Cincinnati, Cincinnati 21

A simple technique for the removal of entire compressions from shales has been recently developed. The new technique is essentially a modification of M. L. Abbott's (1950) "A Paleobotanical Transfer Method," in which sheet acetate and colorless nail polish are employed. The latter method as well as the one to be described herein are laboratory techniques. Consequently, both are preliminary in that the ultimate goal is the development of a simple method by which compressions may be removed from shale under field conditions. Data at hand strongly suggest that the ultimate goal will be attained in the relatively near future.

In recent months, users of the sheet acetate-nail polish method have experienced some difficulty in removing compressions from certain shales. For example, bubbles develop between the nail polish and sheet acetate some 6 to 12 hours after application of the softened acetate. In order to obtain satisfactory transfers, the carbonized plant film and the sheet acetate must be completely bonded together. The precise cause of bubble formation has not been determined to date. However, the sheet acetate manufacturer has converted recently to cellulose triacetate. This may account, in part, for the fact that shrinkage of the sheet acetate during drying has increased materially. This seems to account for concentrations of bubbles centered on minor depressions in the shale and fossil surfaces. But since many bubble areas are not associated with visible surface irregularities, it is probable that some of the bubbles may be due to the entrapment of volatiles given off by the softening agent.

The following modified schedule has yielded a very high percentage of excellent transfers.

SCHEDULE FOR SHALES

1. "Dry fossiliferous rock 24 to 48 hours in usual manner. Be sure surface of fossil is clean and free from extraneous debris" (Abbott, 1950).
2. "Cover fossil and adjacent rock surface with a very thin seal coat of . . ." colorless "nail polish; break all bubbles as they form.
3. "Dry for 30 minutes at room temperature.
4. "Apply a second coat of polish, again breaking bubbles as they form.
5. "Dry at room temperature for at least 30 minutes . . ." (Abbott, 1950).
6. Brush on a heavy coat of a mixture consisting of one part clear spar varnish and twenty parts colorless nail polish. Break all bubbles as they form.
7. Dry at room temperature for at least 36 hours.
8. Apply a second coat of the varnish-polish mixture; dry at room temperature for at least 48 hours.
9. If the carbonized plant film is heavy or if relatively large-leafed species are being treated, apply a third coat of the varnish-polish mixture; dry at room temperature for at least 60 hours.
10. Loosen the peripheral portion of the plastic film not underlain by the fossil with a scapel.
11. Using the side of a scapel blade (dull edge toward fossil) as a support and keeping it as close to the rock surface as possible pull the plastic film and its adhering fossil plant from the rock.
12. If necessary, place the transfer in a dilute (20–25%) hydrofluoric acid bath to loosen the clinging rock matrix.
13. At intervals of approximately five minutes, remove the transfer from the

acid bath; immerse in an excess of luke-warm water to neutralize the acid; brush gently to remove loosened rock matrix; repeat steps 12 and 13 until the rock matrix has been removed.

14. Dry between lens tissues or lintless blotters under a smooth weighted surface for approximately 12 hours.

15. Clear any blushing that may have occurred while the varnish-polish coats were drying or while the transfer was immersed in the acid bath by applying one or two thin coats of colorless nail polish to the shiny side of the transfer; dry free from dust for 12 to 24 hours. The transfer becomes very limp shortly after being coated with polish and must be handled with care; however, the transfer soon regains its original stiffness.

16. Print catalogue number with India ink on the dull side of the transfer and cover the number with polish.

17. Store in glassine envelopes, with plant surface to shiny surface of the transfer to prevent films sticking together or

18. Trim; clear for a few seconds in xylol; and mount, plant side up, in Canada balsam.

DISCUSSION

Approximately 750 carbonized plant compressions have been removed successfully by this technique. Of these, more than 95% exhibit slight to no fragmentation of the carbonized plant film. Specimens collected four years ago have been removed from shale with equal success. Surface dry specimens have been treated within an hour after collecting with satisfactory results.

The principal advantages of this technique are that it is relatively inexpensive, simple, and rapid. If labor costs are disregarded and nail polish is purchased by the gallon, average size specimens can be treated at a cost of approximately one-half cent per specimen. Working as a team, the authors prepare nominial size specimens, steps 1 through 9 of the schedule, at the average rate of 30 specimens per hour.

Four commercial brands of colorless nail polish have been used to coat the fossils and to prepare the varnish-polish mixture. All have proved satisfactory. Five different standard commercial brands of clear spar varnish have been used to prepare the varnish-polish solution.

The varnish-polish mixture is prepared in small quantities by adding the varnish to the polish and then stirring vigorously for 5 to 10 minutes. Frequently, when the relative humidity is high, a white mucous-like mass forms around the end of the stirring rod. This should be removed from the mixture and discarded. When stirring has produced a uniform, bubble-filled mixture, the container is tightly capped and set aside for two or three hours. At the end of that period the bubbles will have broken, and the varnish-polish mixture, which is now ready for application to the pre-treated fossil and adjacent rock surface, is uniformly honey-yellow in color. On prolonged exposure to the air, the varnish-polish mixture becomes viscous. It may be thinned to a workable consistency by adding a small volume of fresh polish.

Minor surface irregularities, such as small pits and grooves, adjacent to and in the fossil present no special difficulty to obtaining satisfactory transfers, provided the depressions are well-filled with polish and the varnish-polish mixture and all bubbles broken. On drying, the depressions are filled with plastic "beads," which adhere strongly to their containing walls. Consequently, the transfer will tend to tear if it is removed too vigorously from the shale. The tendency to tear may be readily prevented by excavating each "bead" with the point of a scapel while the transfer is being pulled from the rock. The plastic "beads" can be flattened without damaging the adjacent plant film by gently pressing them down with the flat side of a scapel blade. For best results, surface irregularities should be reduced or eliminated in so far as practical. However, if care is exercised, specimens may

be removed from very irregular surfaces without special treatment, other than moderately beveling sharp edges and corners.

The varnish-polish mixture frequently blushes during drying. Experience shows that blushing is of two types, only one of which is detrimental to the final transfer. If the relative humidity is moderate, the drying varnish-polish mixture turns slightly white. Except for a slightly thickened transfer film, this type of blushing is not objectionable since it can be cleared later by the application of one or two coats of colorless polish. In fact, better results are obtained when heavily carbonized foliage is being removed if slight blushing does occur. But when the relative humidity reaches 75% or above, the drying mixture not only turns white within a few minutes after application, but also thickens appreciably due to the formation of countless minute bubbles. If the transfer is permitted to cure, it will be opaque and up to one-thirty-second of an inch thick. Critical specimens may be saved by immediately washing off the fluid varnish-polish mixture with beta-methyl-cellusolve (distributed by the Works Laboratory, Carbide and Carbon Chemical Co., South Charleston, West Virginia). The specimen should thoroughly dry before re-coating with nail polish. After the polish has dried, the varnish-polish mixture may be applied in the scheduled manner.

The drying periods proposed in steps 7 through 9 of the schedule are the minimum necessary to obtain consistently satisfactory results. Premature removal of transfers from the rock invariably results in shearing of the carbonized foliage or scaling off of carbon or both. Prolonged drying of the last coat of the varnish-polish yields a brittle transfer which breaks excessively during removal from the shale.

After storage for several months, the transfers become somewhat brittle. To minimumize breakage of specimens in active use, ragged edges of the transfers should be trimmed. Then the transfer may be mounted temporarily between sheets of clear plastic. Small specimens are permanently mounted in balsam on standard slides. A few specimens have been mounted experimentally in a high index media, piccolyte in 50% xylol. Clearing in xylol is unnecessary when this mounting media is employed. This media gives excellent definition to the finer foliage elements and to almost transparent foliage. However, until a satisfactory experience record has been built up, it cannot be recommended for general use.

The authors gratefully express their appreciation to J. H. Hoskins, Department of Botany, University of Cincinnati, for constructive criticism of the manuscript.

LITERATURE CITED

Abbott, M. L. 1950. A paleobotanical transfer method. Jour. Paleo., 24: 619–621.

Laboratory Manual for Brief College Chemistry. *Leon B. Richardson* and *Andrew J. Scarlett.* Henry Holt and Co., New York. Revised edition, 1951. viii+229 pp. $2.00.

This laboratory manual is written to accompany *Brief College Chemistry*, a textbook by the same authors. The exercises follow the same order as that of the subject matter in the text, with page references included.

The format and the large clear type make this an attractive book; the wire binding permits the pages to lie flat when the manual is in use.

The instructions for each experiment are as brief as possible and generally well written. Questions and answer blanks appear on separate report sheets for ease in checking and grading. The arrangement also tends to eliminate the cluttered, chopped-up appearance common to so many General Chemistry manuals. Illustrations and diagrams of set-ups, however, are too few and too small.

The authors claim no originality for the experiments—their purpose was to select from all the material usually encountered in an elementary course such experiments as best fitted the text. A number of the exercises are quantitative in nature and should interest and challenge the better students.

The manual, then, should prove satisfactory not only for classes using the Richardson and Scarlett text, but could be adapted to fit most General Chemistry texts.

ALBERTINE KROHN

PENECONTEMPORANEOUS EROSIONAL SLUMP STRUCTURE NEAR MINERAL CITY, OHIO

HENRY H. GRAY AND DWIGHT E. ARNOLD
Department of Geography and Geology, Kent State University, Kent, and Canton, Ohio

Complex structural disturbance of Pennsylvanian sedimentary rocks near Mineral City, Ohio, is interpreted as the result of slumping of partially consolidated sediments into a valley of Pennsylvanian age and burial by later Pennsylvanian sediments which are undisturbed. Study of such structures is of value to both the coal and petroleum industries as well as to stratigraphers and sedimentologists.

The area discussed is located in northeastern Tuscarawas County, Ohio, near Mineral City, in Sandy Township (fig. 1). The structure is exposed in the Baltimore and Ohio Railroad cut through the divide between Sandy Creek and Huff Run (fig. 2). Old state route 8 crosses this cut on a bridge; the new route is located some 1000 feet to the east.

FIGURE 1

FIGURE 2

FIGURE 1. Index map of Ohio showing location of Tuscarawas County and Sandy Township.
FIGURE 2. Sandy Township, showing localities mentioned in the text. Based on U. S. Geological Survey map of Dover Quadrangle, with corrections.

This exposure was opened when the Cleveland Terminal and Ohio Valley Railroad (now a part of the B & O) was carried into Mineral City (then Mineral Point) about 1880. Since then the steep tilting of the rocks there exposed to view has confused and baffled three generations of geologists. The earliest explanation, proposed by Orton (1884, p. 263), that "a considerable disturbance occurred near the end of the Lower Coal Measure period" appears to suggest a tectonic origin. This is not looked upon with much favor because of the very local nature of the disturbance and the variety of horizons at which it occurs in the vicinity. It has since been relegated to the category of "one of those things" which are found in the Pennsylvanian rocks, are highly disturbing both to the rocks and to the geologist, and are therefore conveniently ignored.

The cut itself is about 1000 feet long and 50 feet deep, and exposures along its sides are still good. They were mapped in the spring of 1950 by Arnold, using the

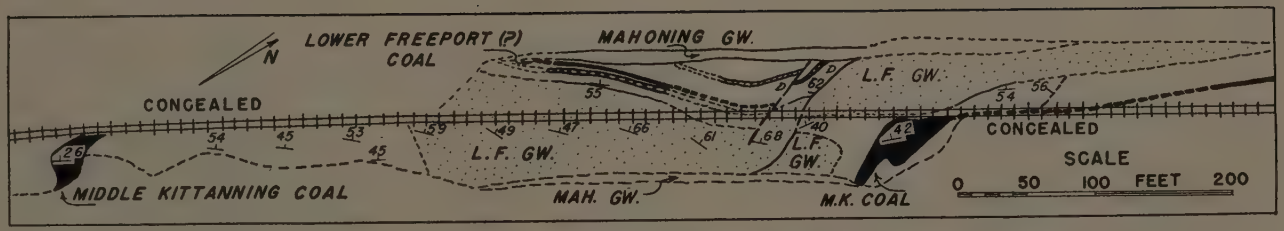


FIGURE 3. Areal geologic map of B. & O. R. R. cut 1 mile northwest of Mineral City, Ohio. D indicates downthrown side of faults. Dips given in degrees. Geology by D. E. Arnold.

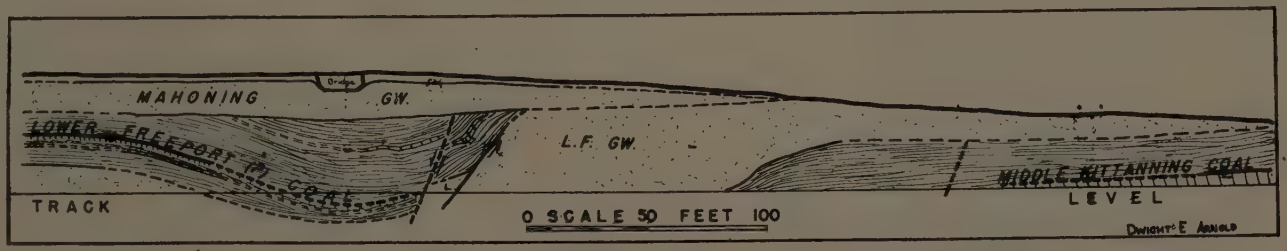


FIGURE 4. Profile of rocks exposed on northwest side of B. & O. R. R. cut. Positions taken from plane table map; elevations measured by hand level. Vertical and horizontal scales the same.

plane table. A stratigraphic section was measured in the spring of 1951 by Gray. The results are illustrated in figures 3–6.

The general form of the structure is that of a small syncline which pitches steeply northwest and is cut by at least three small normal faults. Only one of these is of much displacement. The surface of this fault, the middle one on the map (fig. 3), dips approximately west, and the slip appears to be obliquely down and to the northwest. The smaller faults appear to parallel this one, but are less well exposed.

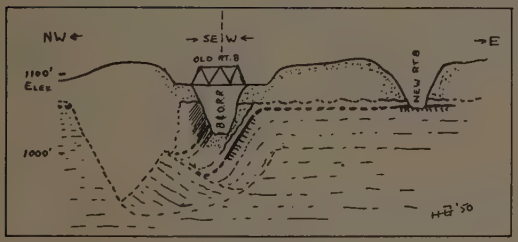


FIGURE 5

FIGURE 5. Sketch cross-section of B. & O. R. R. and new highway cuts, showing observed structure (solid lines) and inferred structure (dotted lines). Vertical exaggeration about five times; dip angles not exaggerated.

FIGURE 6. Columnar section of rocks exposed in B. & O. R. R. cut. All strata below Mahoning graywacke are tilted at angles up to 66 degrees. Measurement by tape, Brunton compass, and plane table.

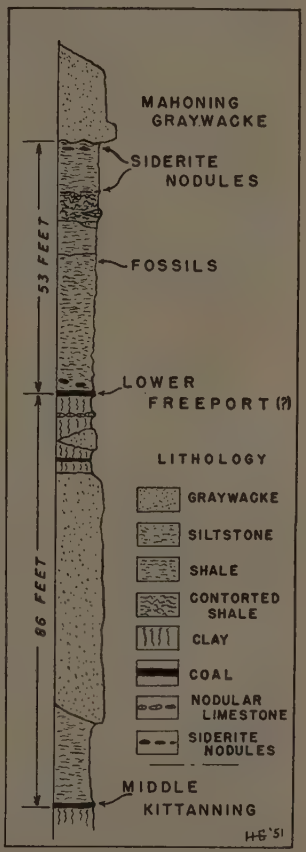


FIGURE 6

The oldest rocks in the cut are the Middle Kittanning coal and underclay. These are exposed in the extremities of the cut with rather moderate dips. Near the center of the cut, however, the dip of this coal is 42 degrees, formerly shown in a miniature flatiron held up by the coal. This unique feature unfortunately disappeared during the severe 1950–1951 winter, probably into the stove of some nearby farmhouse. Stratigraphically above this, mostly near the center and on the northwest wall of the cut, appear the rocks shown in the columnar section

(fig. 6), all except the uppermost dipping at angles up to 66 degrees and generally northwest.

The inclined beds are bevelled about half way up the sides of the cut by a massive graywacke of horizontal attitude. This rock is tentatively referred to the Mahoning sandstone (lithologically a graywacke), following the usage in previous reports (Orton, 1884, p. 263). Discontinuity of exposures has prevented the correlation of this unit with certainty.

About half a mile north of the cut in the opening of an old drift mine, the Middle Kittanning coal lies horizontally about 6 feet below the upper graywacke, and to the east, in a portion of the highway cut, the same relationship is found. In fact, throughout the nearby area this rock lies but a few feet above the coal, though the relief at its lower contact is at least 14 feet, as seen in exposures in the highwall of a strip pit about a mile west of the B & O cut.

Truly tectonic folding is not considered likely as a cause of this structure, since such severe contortion could only be the result of a compressional force strong enough to be felt over a much wider area. Furthermore, the shape of the fold differs from those which are clearly tectonic.

Hypotheses which must be entertained regarding the origin of this structure include several of the mechanisms classed as penecontemporaneous or contemporaneous deformation. Classified genetically, these mechanisms may be listed as follows:

1. Tectonic. Slumping of unconsolidated sediments as a result of folding or faulting.
2. Depositional. Sliding on initial dip.
3. Erosional. Slumping into channels, off sea cliffs, etc.
4. Diagenetic. Differential compaction of sediments.
5. Glacial. Contortion of glacial deposits by overriding.

Since the disturbed rocks are not of glacial origin and lie without the glacial boundary, glacial action may be eliminated as a possible cause. Diagenetic folding results in only gentle folds, and may therefore be dismissed also.

Tectonically produced slumping is unlikely as a cause of this structure since the area in general is devoid of strong enough dips to produce sliding and folding of this sort. The regional dip in this area is less than a degree, and no evidence exists that it ever was significantly larger.

The hypothesis of sliding on initial dip is less easily disposed of. It is thought by many geologists that the coals were deposited as essentially horizontal layers, but there is little proof of this. However, the wide variety of sedimentary rocks involved, plus the fact that none of them possess any of the criteria described by Rich (1951) as diagnostic of the clinothem, in which such sliding commonly takes place, are believed unfavorable to this hypothesis.

It is proposed that this structure is the result of slumping of these Pennsylvanian rocks, shortly after their deposition, into the valley of a stream on the outside of an entrenched meander. This was followed by alluviation of the valley, truncation of the slumped beds and removal of some of the horizontal beds by lateral erosion, and burial by later Pennsylvanian sediments.

First there was deposited a sequence of rocks only a part of which remain in this area (fig. 7, stage 1). These included the Lower Freeport (?) coal, 86 feet above the Middle Kittanning, and at least 53 feet of shales and limestones above this coal, the greater part of which is not now found in this vicinity outside of the area of the B & O R. R. cut. These poorly consolidated sediments were cut by a meandering stream to a depth which must have exceeded 150 feet (fig. 7, stage 2). The soft sediments on the undercut bank slumped, bent, and faulted into the valley (fig. 7, stage 3). Some beds were contorted by this process, but most appear to have been sufficiently cohesive to maintain their primary structural characteristics. The fissile character of the dark shales, and the blocky fracture

of the coals appear unchanged by the deformation. The valley was then filled, and erosion bevelled the tilted beds and removed most of the adjacent horizontal sediments to within a few feet of the level of the coal. On this surface, as well as in the valley, the Mahoning graywacke was deposited (fig. 7, stage 4). It is thought that the periods of erosion and deposition were not separated by any great length of time, and that both were probably fluvial. A marine origin of the valley is considered possible, but not likely; a subaerial valley appears more readily produced than a submarine canyon, the origin of which would be the subject of some controversy.

The result is shown in a section (fig. 5) which crosses both the railroad and highway cuts. Fracture cleavage in the Middle Kittanning underclay, indicating a relative upward movement of the coal over the clay, and the elevation of the

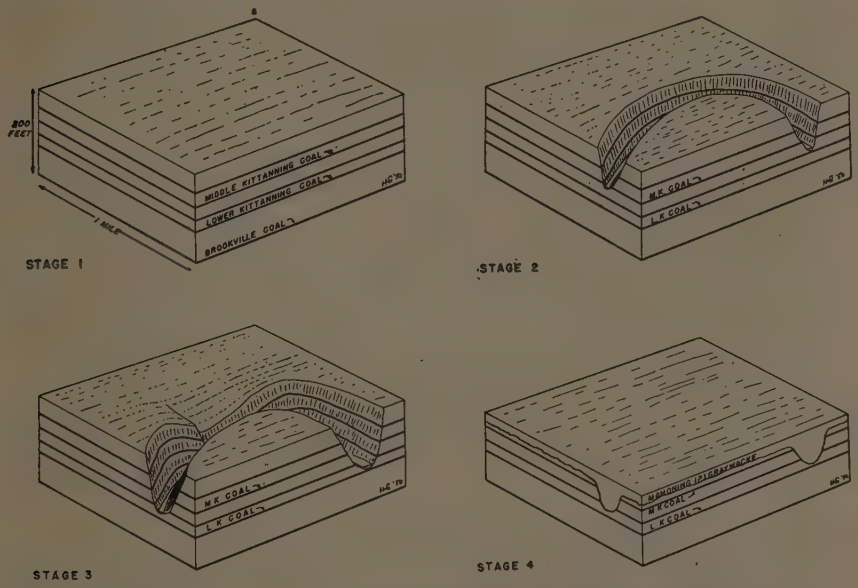


FIGURE 7. Inferred stages in the development of the Mineral City erosional slump structure. All views looking south.

Middle Kittanning coal in the highway cut and in the drift mine to the north, tend to confirm this view of the structure. Because of this disturbance, the immediate area has not been strip mined, and old drift mines nearby have not been successful. Deep gas wells both to the east and to the west of the section illustrated have reported no coal.

Similar structures have been mapped by Ferm (1948) near Brookville, Pa., where they are associated with thickened "shoestrings" of graywacke which have a dendritic pattern and appear to represent the old filled valleys. The Brookville area has been extensively strip mined and the continuity of the exposures there leaves little doubt of the origin of the structures. Channels at the base of what appears to be the Mahoning graywacke are known in the Mineral City region, but careful tracing and mapping of them has not been possible up to the present writing.

Similar structures are found elsewhere in the Mineral City region. They were long ago reported in several of the old drift mines for coal, both here and at nearby Zoar. In one mine the Lower Kittanning coal was reported to have been folded upon itself and thickened from its usual 3 to as much as 13 feet (Newberry, 1878, p. 65). A half mile west of the B & O cut the Lower Kittanning coal is cut out in a strip mine against a bed of steeply dipping graywacke, probably the same one found tilted in the railroad cut. The tilted beds dip northwest toward the slip surface, and the coals in the slumped block (two coals are seen) roll irregularly. A mile southwest of Mineral City, the Lower Kittanning coal is again cut by a similar structure, well exposed to view. In this case the tilted beds consist of unidentified varicolored siltstones dipping southeast against a northwest dipping slip surface—a typical slump structure.

Nor are such structures confined to this region. Other examples, some less spectacular, are known at Dover Dam, East Sparta, East Canton, North Benton, and Lowellville, Ohio. They are known in West Virginia, near Wellsburg, and in Pennsylvania, at Rochester and Kittanning as well as at Brookville. These involve rocks of the Pottsville, Allegheny, and Conemaugh formations, but the strata associated with the Kittanning Coals appear to be the most profoundly affected.

Somewhat similar structures have also been noted in the Fort Union formation of North Dakota (Townsend, 1950; Benson and Golder, 1950) and in Tertiary formations of South Dakota (Toepleman, 1923). All of these disturbances involve lignitic deposits, but those in North Dakota have been referred to a tectonic origin.

Delineation of these structures is of practical importance in coal mining, for they disturb and displace the coals and weaken the rock structure in such a way as to make mining physically and financially risky. Distinction of these from truly tectonic structures is important in the search for oil and gas, as they rarely extend to any great depth. Such a structure might well form a suitable trap for petroleum, but its prediction in the subsurface would be difficult.

Detailed mapping of slump structures may yield more information of academic or practical interest on the pattern and habits of the agents of erosion and deposition during Pennsylvanian time. They are worth more intensive study than they have as yet been given. The authors would welcome additional information on such features in Ohio and elsewhere.

REFERENCES

Benson, W. E., and **C. R. Golder.** 1950. Paleocene deformation in North Dakota. (Abstract) Geol. Soc. Am. Bull., 61: 1444.

Ferm, J. C. 1948. Cyclothems of the Upper Allegheny and Basal Conemaugh groups near Brookville, Jefferson Co., Pa. Unpublished M.S. thesis, Depart. of Earth Sciences, The Pennsylvania State College, State College, Pa.

Newberry, J. S. 1878. Report of the Geological Survey of Ohio, Vol. III, Geology and Paleontology. Pp. 52–89, Geology of Tuscarawas Co.

Orton, E. 1884. Report of the Geological Survey of Ohio, Vol. V, Economic Geology. Pp. 256–283, Coal Mines in Tuscarawas Co.

Rich, J. L. 1951. Three critical environments of deposition, and criteria for recognition of rocks deposited in each of them. Geol. Soc. Am. Bull., 62: 1–20.

Toepleman, W. C. 1923. The Possibilities of oil in eastern Harding Co. S. Dak. Geol. Sur. Circ., 12.

Townsend, R. C. 1950. Deformation of the Fort Union formation near Lignite, North Dakota. Bull. Am. Assoc. Pet. Geol., 34: 1552–1564.

A LIMNOLOGICAL STUDY OF AN OHIO FARM POND

VINCENT SCHULTZ[1]

Department of Zoology and Entomology, The Ohio State University, Columbus 10

The interactions of organisms and their environment must be considered when establishing a sound fish management program. Reports on the development of new fish management practices for farm ponds have not in general been accompanied by the biological, chemical, and physical data upon which such practices were developed.

Limnological studies, even for ponds other than farm ponds, are few in number. Wiebe (1929, 1930, 1934) and Surber and Olson (1936) published data on the biological and chemical conditions existing in hatchery ponds. Their papers are among the few that contain detailed data on selected conditions in such ponds. In the literature there are a few studies on the biological, chemical, and physical conditions of "farm" ponds. Fritsch and Rich (1909, 1913) conducted a four year study on one pond and a five-year study on another in the British Isles; Whitney (1942) studied diurnal fluctuations of oxygen and pH in two small ponds in the British Isles; Laurie (1942) investigated the fauna of an upland pond in Wales; Ward (1940) studied selected chemical conditions and the Entomostraca of a "sheep" pond in Ohio; and Greenbank (1945) studied several winter chemical conditions of an "artificial" pond in Michigan.

The study presented here is an attempt to describe and analyze selected biological, chemical, and physical data for 16 months from a farm pond near Columbus, Ohio. No attempt was made to manage this pond or to solve any problems of farm pond management; the study was initiated to investigate some conditions existing in a specific pond with the immediate purpose of exposing problems for future study. The results of this study indicate that such problems are related to: (1) The influence of an algal surface cover on some physical, chemical, and biological conditions. (2) The dominance of zooplankters, especially rotifers, in the net plankton. (3) The reappearance of similar genera and physical and chemical conditions in successive years. (4) Daily and seasonal variability in biological, chemical, and physical conditions.

LOCATION AND DESCRIPTION OF FARM POND

The pond is located in Franklin County, Ohio, on the Ohio State University Farm. At high water it is approximately one-half acre in area; a dam extends approximately north and south and the pond proper extends westerly from this dam. During the period of study the greatest maximum depth was approximately seven feet and the lowest maximum about five feet (fig. 1).

The watershed is of soils of the Miami Catena, consisting of Brookston silty clay loam, Celina silt loam, Crosby silt loam, and Miami silt loam; it is predominately of Celina silt loam and Miami silt loam. The watershed has a slope of 2 to 5 percent with slight-to-moderate sheet erosion. During the study, the watershed, exclusive of a woodlot located to the southwest of the pond, was covered with alternating fields of corn and alfalfa transected by sodded waterways. So far as can be determined, water drainage into the pond is primarily from the farmed area. The position of a small tile at the bottom of the pond indicates drainage from a small woodlot, on Crosby silt loam, to the southwest.

Initial construction of the pond was completed by August 25, 1944. As a result of water seepage, a state of repair existed until the summer of 1946. Five

[1]Present address: Tennessee Game and Fish Commission.

tons of No. 200 Bentonite were used to prevent seepage after drainage tile were removed from the pond. From the completion of excavation until the fall of 1946, when fish were stocked, the pond was twice filled with water.

METHODS

General

The net plankton and algal mat, as well as selected chemical and physical conditions, were studied at weekly intervals for 16 months and some studies on a daily basis. From initiation of the study on April 2, 1948, until June 21, 1949, no attempts were made to disturb the pond in any way. On June 22, 1949, a study was initiated to determine the effect of the removal of the algal mat on selected

FIGURE 1. Farm pond at low water, November 4, 1948.

biological, physical, and chemical conditions. When collecting net plankton and water samples, the air temperature, wind direction, wind velocity, sky condition, occurence of precipitation, and the pond surface condition were recorded.

Hydrogen-ion concentration, vertical plankton distribution, bottom organisms, and various chemical constituents of the water were not studied.

Biological

Net plankton. Net plankton were collected by pouring 90 liters of pond water through a No. 20 bolting silk plankton net. Transeau's preservative (6 parts distilled water, 3 parts of 95 percent ethyl alcohol, 1 part formalin) was added to the concentrated sample from the net until a volume of 45 cc was obtained. Plankton and water samples were collected in the vicinity of the overflow. Plankton were collected from a restricted area only during periods of ice cover and when the

algal mat encroached on the "overflow area." For example, periods of algal mat encroachment occurred during July 1948; the open area adjacent to the platform was estimated as 36 square feet on the first of the month; 16 square feet on the 8th; less than 16 square feet on the 15th; 28 square feet on the 22nd; and more than 120 square feet on the 29th. At such times the algal mat covered almost completely the entire pond surface.

A special plankton "collection shelter" for use during winter was placed in the overflow and used during most of the study. A small kerosene brooder stove was used in the shelter during winter to prevent freezing of the plankton net.

Differential counts of net plankton were made in a No. 800 Sedgewick-Rafter counting chamber. Using a 1 cc pipette with an enlarged opening, 1 cc of the concentrate was placed in the counting chamber. Twenty-four evenly spaced cubic millimeters, 8 in each of three parallel rows, were counted through a 16-millimeter objective and a 10x ocular. Ten 1 cc portions were counted so that an average value might be obtained. Replications were undertaken in the event that the significance of the difference between the average values obtained during different sampling periods might be arrived at by statistical means. The 24 cubic millimeters counted were not selected at random since, according to the investigations of Littleford, *et al.* (1940), there is no apparent advantage in a random selection. They state, "It has been found that counts based upon the selection of groups of areas at random are about the same as those obtained according to selection."

In general, organisms have been identified to genera. The difficulty of identifying preserved ciliates, unless identification of a certain genus was thought reliable, resulted in their being classed as one group (ciliates). Filamentous forms common to the algal mat occurred rarely in the counts and were not tabulated. Because of difficulty in identifying fragments of certain filamentous Myxophyceans all such forms were classified as *Oscillatoria*. An example of such a form is *Lyngbya*, the only filamentous Myxophycean similar to *Oscillatoria* that was identified. All filamentous forms tabulated were recorded as one individual, irrespective of length. *Synedra* and *Navicula* were tabulated as naviculoid forms.

As a result of difficulty in separating preserved Bdelloids from small contracted "sac-like" rotifers, such as *Synchaeta*, these forms were all tabulated as "sac" rotifers. The relative abundance of these two groups, as determined by observing samples containing living organisms, is discussed later. With the exception of "spinous processes," organisms were counted as complete, irrespective of the amount of the organism appearing within the one cubic millimeter counted. Organisms believed dead prior to preservation were tabulated; for example, diatoms as frustules; Entomostraca and Rotifera as dead metazoans. All forms, whether "dead or alive," "complete" organisms, or eggs, were tabulated in the total count.

Algal mat. Samples from various areas of the algal mat were collected and the organisms present were tabulated as to relative abundance.

The errors and precautions involved in the methods employed in sampling, identifying, counting, and tabulating are for the most part obvious and have been discussed adequately elsewhere (Littleford, *et al.*, 1940; Welch, 1948; Ricker, 1932; Allen, 1930; Taft, 1949; Lackey, 1939).

Physical and Chemical

Physical. General physical conditions existing at the time of sampling were recorded in relative terms. Air temperatures, taken in the shade, and water temperatures were determined with a mercury thermometer. Temperatures were estimated to 0.25° C.

A Secchi disk, 6 inches in diameter, was used to estimate the extent of light penentration. Sky conditions were recorded as clear, partly cloudy, or overcast.

Wind conditions were recorded as calm, slight, or heavy. The wind direction was estimated to the nearest half quadrant.

"Open water" surface conditions in the area of sampling were classed as calm, slight ripples, or heavy ripples. Due to the location of the pond in relation to the small woodlot and surrounding topography, winds of similar velocities from different directions did not have the same effect upon the surface of the sampling area. Those from the southwest, west, and northwest appeared to have the greatest effect on the surface where sampling occurred. Precipitation was recorded as absent or present during the time of sampling.

Weather conditions during the week prior to sampling probably had a major effect on the pond. Therefore, the maximum and minimum temperatures and precipitation as recorded at The Ohio State University Weather Station were studied. Although this station is approximately one mile from the pond, these data probably present a general picture of conditions that existed there.

The time of sunrise and sunset, as well as the time of collection, was recorded so that the effects of photosynthesis might be fully evaluated. It is believed that the hour of collection, often not recorded in limnological papers of this type, is an essential for complete data.

Chemical. Water samples were collected with a Foerst water sampler (12 inch cylinder). Samples were taken at the surface (refers to open water, i.e., no algal mat present), at the bottom and in the algal mat. Water in the algal mat was obtained merely by making a small hole in the mat and inserting the sampler just below the surface. Samples were also collected in open water areas in the mat and in portions of the mat on the bottom of the pond. Chemical determinations were started within 15 minutes after collecting the last sample. All samples were collected within 5 minutes of the time designated on the data sheets.

The dissolved oxygen content was determined by the Rideal-Stewart modification of the Winkler method (American Public Health Association, 1946). A starch solution (after Ellis, *et al.* 1946) was used as an indicator and correction was made for the addition of reagents. Oxygen saturation values were determined, when possible, by means of a nomogram from Rawson (1944) and others calculated from the tables of Whipple and Whipple (American Public Health Association, 1946). Saturation values were calculated to the normal pressure of the region.

Free carbon dioxide, hydroxide (OH^-), normal carbonate ($CO_3^=$), and bicarbonate (HCO_3^-), were determined according to Ellis, *et al.* (1946). A 250 cc Erlenmeyer flask was used in place of a Nessler tube for the determination of free carbon dioxide. Xylene cyanole-methyl orange indicator was substituted for methyl orange indicator on June 18, 1948, and used until completion of the study.

Indicators (except the starch solution) and standard solutions necessary for all determinations were obtained from the Control and Reagent Laboratory of The Ohio State University.

DISCUSSION OF OBSERVATIONS

Physical and Chemical

Physical. Air temperature at the time of sampling showed great variability throughout the period of study. A low of −4.5° C was observed January 20, 1949; a high of 35.0° C occurred July 15 and July 22, 1948, and a high of 38.25° C on June 24, 1949. Comparison of these data with those of the university weather station indicates greater extremes in temperature occur at the pond than at the station.

From the latter part of March until the second week of September the temperature of the surface water exceeded that at the bottom. During the remainder of the year, with few exceptions, the surface temperature was lower than at the bottom. The temperature of the water in or under the floating algal mat during

the summer period generally was intermediate between that of the open surface and bottom. During autumn the water temperature in the algal mat generally equaled or exceeded that of the open surface water (fig. 2).

Comparisons of the temperature of pre- and post-noon water samples (fig. 3) indicate that the temperature of the surface and bottom increases with a rise in air temperature, the change at the surface being more extreme than at the bottom. Rainfall during the summer months was followed by a decrease in temperature of the surface water.

As to the temperature of ponds in midwestern United States, Anderson (1948) remarks: " . . . bluegills do not spawn until the water temperature has reached 80° F. (26.7° C), usually about July 1 in this region . . . ." It is true that temperature values as high as 26.7° C were not recorded at the surface, bottom, or in the algal mat until July in the pond studied, but bluegills were observed spawning during May in about three feet of water, when the surface temperature was 22.0° C and the bottom (depth of 67") 21.0° C.

FIGURE 2. Water temperature at time of sampling.

Secchi disk readings taken throughout the year indicated that maximum light transmission in open water occurred concurrently with the presence of an algal mat through the summer and into the late fall. During this period the bottom of the pond was visible. Fessler (1949) also observed that water in heavily vegetated ponds was clear. With the subsequent removal of the algal mat and agitation of bottom materials on June 22, 1949, the bottom was, with one exception, not visible for the remainder of the pond's "existence" (August 30, 1949). Except for a reading on April 16, 1948, minimum Secchi disk readings were obtained during February and the latter part of January.

At the initiation of the study on April 2, 1948, water was pouring into the overflow, but as summer progressed the water level decreased and remained low until late December (fig. 1). Rainfall throughout the summer and fall had little effect on the water level. Comparison of the water level in an evaporation pit (without an algal mat) adjacent to the pond and that in the pond (with an algal mat) indicated that the mat enormously increased the amount of evaporation from the pond. A relatively high water level and the absence of an algal occurred during the summer of 1947.

Chemical. The amount of dissolved oxygen varied extremely (fig. 4). This was probably a result of photosynthesis by algae and a direct result of physical factors such as precipitation and strong winds. Presence of certain plants has been shown to be associated with daily variation in the dissolved oxygen content of water (Wiebe, 1934; Whitney, 1942; Laurie, 1942; Roach and Wickliff, 1934). The dissolved oxygen data obtained late in the spring of 1948 differed radically from those in late spring of 1949; during 1948, the dissolved oxygen content was

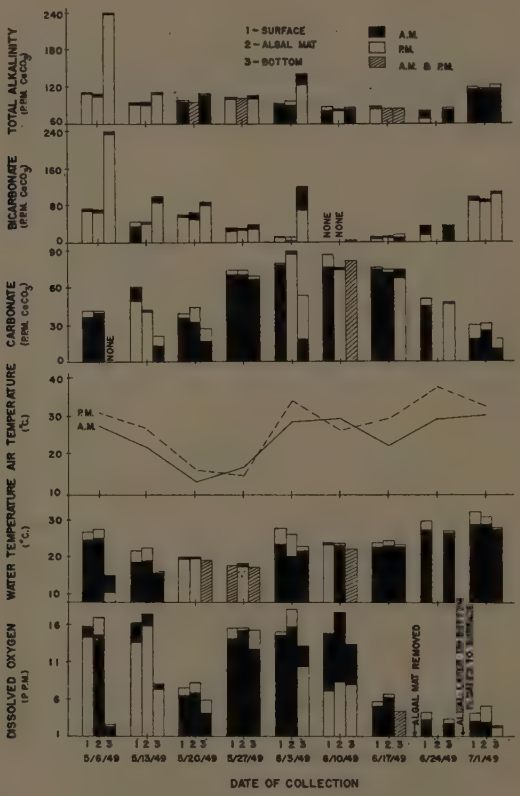


FIGURE 3. Pre- and post-noon physical and chemical determinations.

generally higher at the bottom than the surface. This relationship was reversed concurrently with the rise of filamentous algae to the surface during the week prior to June 24. A limited amount of filamentous algae was present prior to June 24 along the edges and at places extended out a few feet from the margin of the pond. From June 24, 1948, until termination of the study, with few exceptions the dissolved oxygen content at the surface exceeded or equaled that at the bottom. The lack of repetition of similar bottom and surface oxygen relationships in 1949 probably resulted from a period of high air temperature during which an extensive algal mat appeared on the surface during the week prior to May 6, 1949. Results of analyses on June 4, 10, 21, and 29 (fig. 5, 6), substantiate these inferences

regarding conditions during late spring of 1948. The decrease in dissolved oxygen throughout the day of June 10, 1948, in the algal mat, may have been the result of heavy winds.

In general, the lowest dissolved oxygen in the algal mat occurred during late summer and early fall.

According to Moore (1942), "Although more data would be desirable one seems justified in concluding that an oxygen content of at least 3.5 ppm is essential to the maintence of fish life at summer temperature." Only three records of less than 3.5 ppm of dissolved oxygen were found in the present study and these were on bottom samples. Concurrently with a low of 0.1 ppm of dissolved oxygen at the bottom on July 29, 1948, fish were observed at the surface for the first time during midday.

Analysis of data obtained during a 24 hour period on June 4 and 5 (fig. 5), prior to the uplift of filamentous algae from the bottom, poses some interesting problems. Data from water in the floating algae along the shore showed an increase in dissolved oxygen during the hours around midnight, concurrent with a

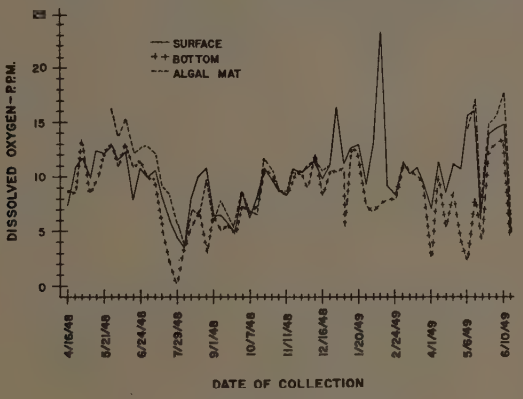


FIGURE 4. Dissolved oxygen values.

decrease of dissolved oxygen in water in the submerged filamentous algae (submerged about two feet); a possible explanation is the movement of oxygen from water in submerged algae to the surface. The reason for an increase in oxygen at the bottom from 4 P.M. until midnight is unknown. The amount of dissolved oxygen in the surface remained fairly constant throughout the afternoon and night. During the period from 4 A.M. to 6 A.M. on June 4, 1948 there was a decrease in the dissolved oxygen in all areas sampled. The decrease was rapid at the surface and slow in the floating algal mat.

Peaks of dissolved oxygen (fig. 4) on December 30, 1948 and February 10, 1949 were accompanied by the largest numbers of phytoplankton, predominately *Chlamydomonas*, observed during the study. A unique feature, on February 2, was a dark green layer of *Chlamydomonas*, about one inch thick, at a depth greater than the Secchi disk reading (about 24 inches). An ice cover ⅜ inch thick existed and the water appeared to be in an unstable condition because it "turned over" at the slightest agitation. The temperature of surface water was recorded as 3° C; silt was present on the lower surface of the ice. The raising of the disk resulted in the observation of this green layer as currents lifted it to the surface. An attempt was made to obtain a sample of this band with a jar as the layer rose to the surface. A count of 1 cc of this sample resulted in a value of 8,456,250

Chlamydomonas per liter. The mixture of the desired sample with "clear" water indicates that the true value was greatly in excess of this value. A somewhat similar condition in which a sudden mortality of fishes was accompanied by a supersaturation of oxygen and a bloom, principally of *Chlamydomonas*, was reported by Woodbury (1941) in a Wisconsin lake during April.

The amount of dissolved oxygen in the algal mat exceeded that both at the bottom and surface; this condition existed for an extensive period until August,

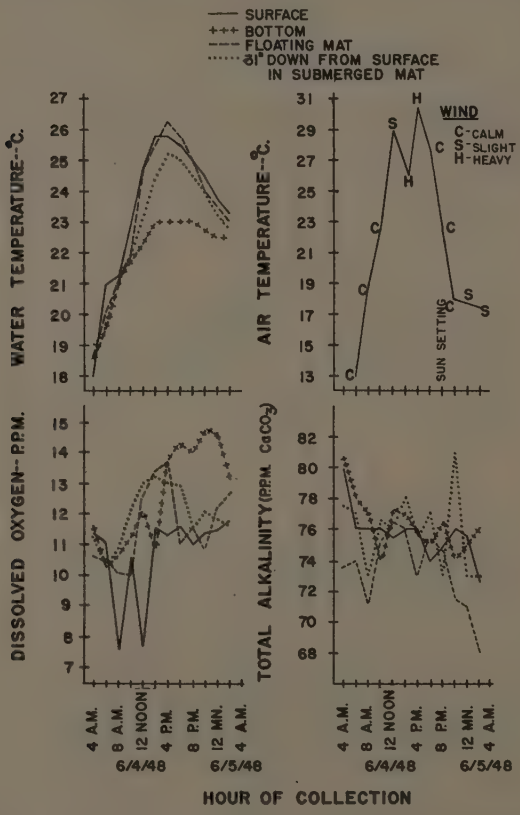


FIGURE 5. Physical and chemical values during a 24 hour period.

after which values greater, less or equal to those of the bottom and surface were found. The simultaneous occurrence of similar physical and chemical conditions of the three sampling areas (surface, bottom, and algal mat) indicates that the fall overturn occurred around September 23, 1949.

Oxygen saturation values during successive samplings were variable (fig. 7); the greatest generally being during spring and early summer. The contours of plotted values for oxygen saturation and dissolved oxygen in the three locations were very similar (fig. 4, 7). Supersaturation values were the rule rather than the exception in spring and early summer. Only six supersaturation values were obtained in the period from August 12, 1948 to April 1, 1949; four of these were

in August and two during the "bloom" of *Chlamydomonas* in December and February. Reports of super-saturation values of dissolved oxygen in relation to green plants are common in the literature (Wiebe, 1934; Laurie, 1942; Moore, 1942; Birge and Juday, 1911; Woodbury, 1941; Smith, 1934).

The absence of free carbon dioxide from April 23 to July 15, 1948, coincided with a period of high dissolved oxygen. Free carbon dioxide was detected on April 16, 1948 at the surface and bottom. No determinations were made on samples from the limited algal mat on this date. Free carbon dioxide was not detected in any sample from April 17 through July 21, 1948. It was detected from

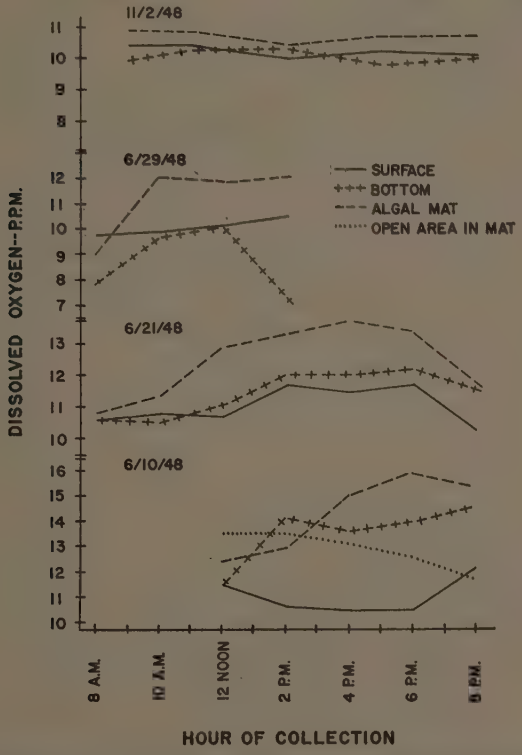


FIGURE 6. Daily dissolved oxygen values illustrating possible influences of algal mat.

July 22, 1948, to August 12, 1948 on the bottom; July 29, 1948 to August 5, 1948 on the surface; and only on August 5, 1948 in the algal mat. These periods were accompanied by relatively low dissolved oxygen values. Except for one record at the bottom on August 26, free carbon dioxide was not detected again until September 28, 1948, at which time it occurred simultaneously in the three sampling areas. It was detected, with four exceptions, until spring at the surface and bottom and in the remains of the algal mat until cessation of sampling on December 30, 1948. The exceptions were simultaneous with peaks of dissolved oxygen. The most notable exception was in the surface water on February 10, 1949, when the algal bloom was observed.

Free carbon dioxide values for the algal mat and surface water samples have similar distributions indicating either that similar conditions existed in the two areas or one or both of the areas were exerting a dominant influence on the free carbon dioxide level of the two areas. The longest period of occurrence and the greatest amount of free carbon dioxide was detected at the bottom.

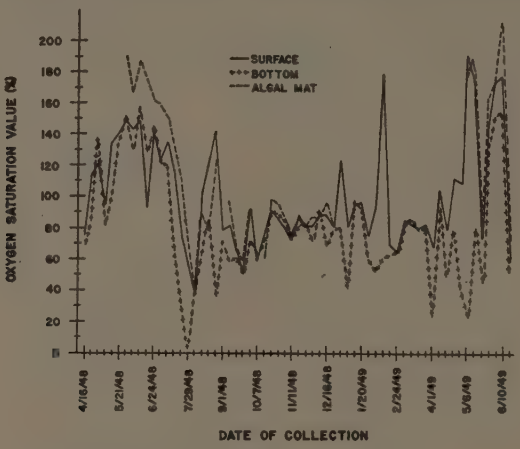


FIGURE 7. Oxygen saturation values.

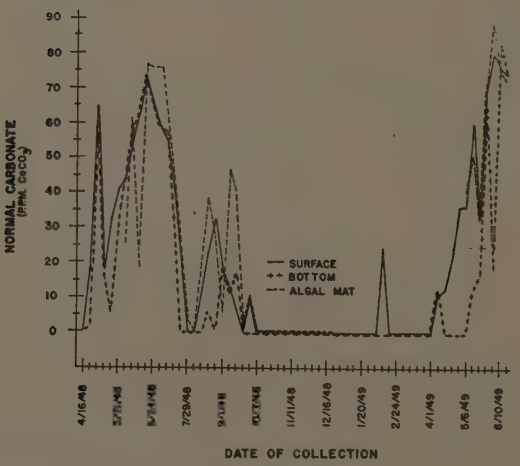


FIGURE 8. Normal carbonate values.

According to Lagler (1949), free carbon dioxide in excess of 20 ppm can be considered harmful to fish; values of less than this may be harmful if low oxygen values exist (less than 3 to 5 ppm). Only rarely did such a combination exist during the present study.

As expected, normal carbonate ($CO_3^{=}$) was detected only during the absence of free carbon dioxide. It was present primarily during spring, summer, and early

autumn with a peak from late spring to mid-summer (fig. 8). During the winter months carbonate was detected only during the algal bloom on February 10, 1949. In general when an algal mat is present, there appears to be an increase in the normal carbonate and a decrease in the bicarbonate content between 10 A.M. and 2 P.M. A tendency for a decrease in bicarbonate during this period is probably

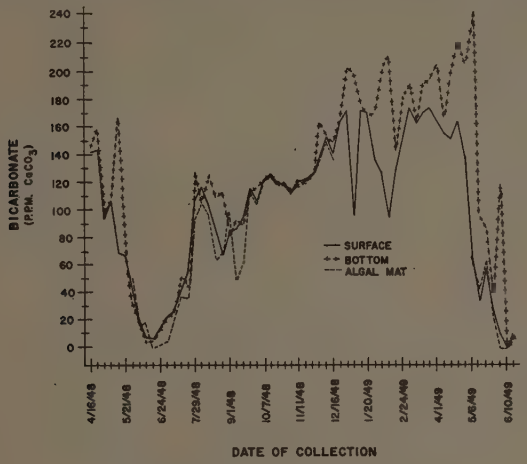


FIGURE 9. Bicarbonate values.

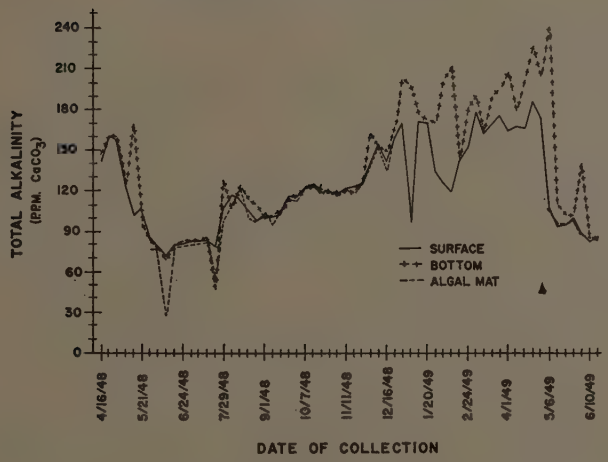


FIGURE 10. Total alkalinity values.

the result of photosynthesis. According to Chambers (1912), in the absence of free carbon dioxide plants use bicarbonates in the photosynthetic process. This is also reported by Smith (1934).

The process may be so vigorous that the bicarbonate is exhausted and the water becomes alkaline (Chambers, 1912). Fritsch, (1931) elaborates this statement:

"So marked a change towards the alkaline side results not only from the conversion of bicarbonate to carbonates but also from a withdrawal of CO_2 from the latter with the production of the hydroxide." Such a relationship existed in the algal mat on June 11, 1948 when the bicarbonate value was zero; the normal carbonate reached a value of 18.3 ppm and 9.1 ppm of hydroxide ($OH^{=}$) were detected.

Bicarbonate was greatest during winter and spring with lowest values occurring during the latter part of May and June (fig. 9). A relatively small amount of bicarbonate was present during the major algal bloom on February 10, 1949 and also one week following an algal bloom on December 30, 1948.

Total alkalinity was greatest during spring and winter (fig. 10). During this period the total alkalinity at the bottom equaled or exceeded that at the surface. During the summer, in the three areas sampled, the lowest total alkalinity generally occurred in the algal mat.

The various relationships between dissolved oxygen, free carbon dioxide, normal carbonate, and bicarbonate, daily and seasonally, offers fairly substantial evidence that the process of photosynthesis was exerting a strong influence on various factors in the pond.

Biological

Net plankton. Results of net plankton counts show that zooplankters were dominant during the spring. During the summer, at different periods, zooplankters or phytoplankters were dominant. Phytoplankters were dominant during winter; in general, they were present concurrently with the presence of free carbon dioxide and a minimum or absence of the algal mat. Diatoms were most abundant during spring. *Cyclotella*, *Gomphonema*, naviculoid forms, *Dinobryon*, and *Mallomonas* appeared to be predominantly spring forms, while *Cosmarium*, *Euglena*, *Pandorina*, *Scenedesmis*, and *Tracholomonas* occurred predominantly during the summer. *Cryptoglena* and *Cryptomonas* occurred during late fall, winter, spring, and early summer. *Chlamydomonas* was observed only during the winter. *Dinobryon* was observed only during the spring of 1948.

According to Hutchinson (1944), *Dinobryon* "appears to increase after the major components of the spring maximum have declined." The separation of *Characium* and *Cryptoglena* in the counting cell was difficult; therefore, when occurring together the numbers counted of these two forms are not accurate.

Zooplankters occurring in greatest numbers were generally rotifers, but during certain periods the Cladocera were dominant. Rotifers included *Anuraea*, *Asplanchna*, *Cathypna*, *Monostyla*, *Noteus*, *Pedalion*, *Philodina*, *Polyarthra*, *Rattulus*, *Schizocerca*, *Synchaeta*, and a few unidentified forms. Rotifers occurred in largest numbers during spring, summer, and fall. *Anuraea* was observed predominantly in spring, summer, and fall; *Asplanchna*, during summer; *Cathypna* and *Monostyla*, during spring and summer; *Polyarthra*, during spring; *Philodina roseola*, during winter; and *Synchaeta*, during winter and spring. *Monostyla* occurred more frequently and in greater numbers than did *Cathypna*. *Pedalion* and *Schizocerca* were observed in large numbers during August, 1949, a period following removal of the algal mat.

The Cladocera observed appear to be spring and early summer forms. *Chydorus* was less restricted in seasonal appearance than *Ceriodaphnia*, *Scapholeberis*, or *Simocephalus*. Of these latter three, *Simocephalus* was the first to appear in spring. It was observed in enormous numbers adjacent to the algal mat but was relatively rare in open water. Five adult bluegills examined had fed heavily upon this form. *Ceriodaphnia* and *Scapholeberis* were observed in large numbers only in open water. Many individual *Ceriodaphnia* were covered with Characium; this was observed during 1948 and 1949. In 1949, *Characium* occurred also on *Trachollomonas* (one observation), *Cyclops*, nauplii, and rotifers.

Net plankton samples collected during various hours of the day showed great

varibility. The results of a twenty-four hour study on June 4, 1948 indicate that an increase in zooplankton at the surface occurs during the latter part of the day. An interesting observation was made on June 10, 1949 when at 10:30 A.M. great numbers of *Scapholeberis* were observed with winter eggs; at 2:30 P.M. no ephippia were observed and the majority of individuals contained parthenogenetic eggs.

With the exception of winter blooms of *Chlamydomonas*, the total number of net plankton was greatest during spring. Far greater numbers of organisms were observed during the spring of 1949 than in the spring of 1948, possibly resulting from manure being placed on the watershed during the winter months or from decomposition of the algal mat during the winter of 1948–49, or both. It is known that no extensive algal mat was present during the late summer and fall of 1947. Whether or not manure was placed on the watershed during the winter of 1947–48 is unknown.

Algal mat. The algal mat which apparently had an influence upon various conditions existing in the pond, possessed great seasonal variability in its composition. Algal samples collected on the upper and lower surfaces of the mat, in shallow water and in deep water, varied in species composition. Exclusive of scarce fragments of the algal mat of the "preceding" year, the first Chlorophyceans appeared in the inlet ditch; they consisted of, in order of occurrence, *Vaucheria*, *Ulothrix*, *Mougeotia* and *Stigioclonium*. These forms disappeared with the warming and disappearance of water in the ditch. *Oscillatoria* was observed prior to the above forms and was present in the pond during the greater part of year. It occurred in greatest numbers in the net plankton during the spring and fall overturns. In the pond proper *Cladophora* was the dominant spring form, but with the advent of warmer temperatures, *Oedogonium* became dominant. On the basis of cell size and form at least two species of *Oedogonium* were present. During the spring of 1948 a mass of pure Cladophora up to four feet thick was present under a surface layer of *Oedogonium*. This relationship was not observed during the spring of 1949, probably as a result of the early rise, in deep and in shallow water, of filamentous algae (primarilly *Oedogonium*) to the surface of the pond. The mat in 1949 was restricted in thickness to a surface layer. Except for occasional patches of *Oscillatoria*, filamentous algae were not observed on the bottom in depths exceeding 5 feet. Patches of *Oscillatoria* were observed on the surface or on the under side of the floating algal mat at various times during the year; excessive occurrence of these patches appeared to be associated with hot weather.

According to Tiffany and Transeau (1927), the genus *Oedogonium* reaches sexual maturity largely in spring and summer. They reported two major crests (May, June) and a minor crest (October) of fruiting. Observations of fruiting *Oedogonium* in the algal mat were made in the farm pond studied. A "small" form was observed in the fruting condition on June 4, 11, 18, 19, 24, July 1, 8, 29, August 12, 1948 and May 5, 1949; a "large" form, on June 19, 24 and November 4, 1948. In no observation was fruiting abundant.

Spirogyra appeared in July, 1948 and persisted into the winter. *Spirogyra* was observed conjugating on August 5, 1948 and October 14, 1948.

Hall (1947) made observations on algae of this farm pond during the summer of 1947. He reports that *Oedogonium* was the only filamentous algae observed in his initial collection on June 19, 1947 and that in a period of one week in the middle of July this form disappeared entirely. This disappearance was probably nothing more than the result of physical destruction of the mat by excessive precipitation occurring on July 14–15; during this period 3.87 inches of rainfall were recorded at The Ohio State University Weather Station. Hall (1947) also reported that by the latter part of July the dominant from of algae was *Euglena*. This was replaced by a species of *Oedogonium*. His description indicates that it was the "large" form observed by the writer. At no time during 1947 was a mat present as extensive as that observed during 1948 and 1949.

Diatoms were observed throughout the year but they varied considerably as to number and location. Diatoms were very rare in the surface layers of the algal mat. The number observed on the lower surface of the floating algal mat showed extreme variation; there they occurred in the greatest numbers during spring and fall. During the winter, fragments of the mat contained large numbers of diatoms. Fritsch and Rich (1913), studying a pond in the British Isles, reported diatoms as being abundant chiefly during the winter months. In "decaying" portions of the algal mat (generally in shallow water at the inlet and end along the margin of the pond) diatoms occurred commonly throughout the period studied. These "decaying" portions also contained the greatest numbers of motile forms of all types. Motile forms were generally rare in "healthy" portions of the mat, an area of no detectable free carbon dioxide. Such observations further substantiate the inference that free carbon dioxide may be a limiting factor in relation to phytoplankton production.

According to Platt (1915) working on "blanket algae" of freshwater pools, four predominate diatoms occurred: *Navicula*, *Synedra*, *Gomphonema*, and *Cocconema* (*Cymbella*). In the algal mat of the farm pond reported on in this paper, *Navicula*, *Synedra*, *Gomphonema*, *Cocconeis* and *Rhopalodia* were the dominant diatoms. The naviculoid forms (*Navicula* and *Synedra*) occurred throughout the year. *Gomphonema* was predominantly a spring and early summer form. *Cocconeis* was observed primarily epiphytic on "decaying" *Cladophora*. The lack of observations of *Cocconeis* during the spring of 1949 probably was the result of the relatively small amount of *Cladophora* present. This inference is substantiated by Fritsch and Rich (1913) who state, "With the absence of *Cladophora* there is lost one of the most suitable substrata for growth of certain epiphytes, this may partly account for the non-occurrence of such forms as *Cocconeis*." *Rhopalodia* was observed only from August 26, 1948 through January 6, 1949. Its period of greatest abundance was during September.

Scenedesmus, *Cosmarium* and *Euglena*, as also observed by Hall (1947), occurred primarily during summer months.

Enormous numbers of *Simocephalous* were observed on the edge of the algal mat. *Chydorus* was the only Cladoceran observed in great numbers *in* the mat and was common during a portion of the spring of 1949. Its absence in the spring of 1948 was probably due to an oversight in neglecting to record certain organisms at the initiation of the study.

Other than algal forms the only aquatic plant observed in the pond was *Potamogeton*. It was common during 1948 in water less than three feet deep. In 1949, prior to the removal of the algal mat, it was scarce, probably as a result of the "early" rise to the surface of the algal mat, but with removal of the algal mat it became common.

In conclusion it might be said that, although the method of sampling offers opportunity for improvement, there appears to be definite time relationships involved in appearance of certain organisms. Data concerning types and numbers of organisms in the algal mat appear to bear very little relationship to similar data on net plankton.

Effects of removal of the algal mat. It should be recalled that natural conditions of the pond were disturbed with removal of the algal mat and that any subsequent observations cannot be considered "typical" for this pond. Previous discussions, unless otherwise stated, referred only to observations made prior to this period of algal mat removal.

Limited observations indicate that there was an increase in the amount of net plankton and a decrease in the amount of dissolved oxygen after removal of the algal mat and subsequent stirring of the bottom mud (fig. 11). The mat was partly removed on June 22, 1949 and was, for all practical purposes, completely removed on June 23, 1949. Removal of the mat, by physical means, was followed by a

rapid growth and an apparently increased photosynthetic rate by filamentous algae, as indicated by patches of filamentous green algae present on the bottom which rose to the surface and in a short time formed a fairly extensive mat. The algal mat was again removed on July 2, 1949 after chemical determinations had been made.

Miscellaneous observations. In addition to the primary investigation, miscellaneous observations were made upon vertebrates and invertebrates occurring within and around the pond.

The fishes and amphibians observed consisted of largemouth black bass (*Micropterus salmoides*), bluegills (*Lepomis microchirus*) and leopard frogs (*Rana pipiens*).

The turbid condition of water during the spring of 1948 and 1949 prevented accurate observations on the initiation of spawning. Bluegills were first observed spawning on May 28, 1948, and May 6, 1949. At no time were bass observed to be

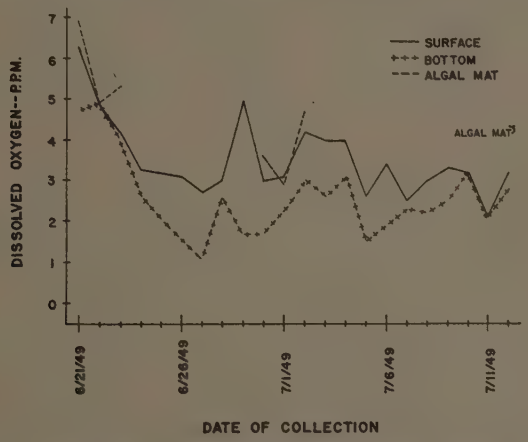


FIGURE 11. Dissolved oxygen values during and following removal of algal mat.

spawning. The absence of observations of bass fingerlings in the summer of 1948 indicates that bass did not spawn that year (the pond was stocked during the fall of 1947 with fingerling bass). Bass fry and fingerlings were observed during the summer of 1949. Extreme differences in the size of young bluegills and bass were quite evident during the latter part of June, 1949; bass were nearly of fingerling size while bluegills were much smaller. Such an extreme difference in size indicates that bass were spawning earlier than bluegills. The algal mat prevented observations on the cessation of spawning; the latest spawning observation for bluegills was on August 12, 1948.

On August 30, 1949, the pond was drained and enormous numbers of small bluegills and black bass were obtained. Eighty-nine bluegills over 5 inches long and 18 largemouth black bass over 11 inches in length were obtained. As far as can be determined these 18 bass plus three removed in the spring approximately equal the number of fingerlings stocked during the fall of 1947. Adult bass showed a growth of about two inches from the first week of April 1949 until August 30, 1949.

Frogs or tadpoles were common at certain periods. Adult frogs were numerous on April 16, 1948 and tadpoles were abundant by May 21, 1948. Frogs were first observed on March 20, 1949, but by April 1, 1949 they had disappeared,

probably as a result of a cold period. They were again observed in large numbers on April 22, 1949, followed by tadpoles on May 6, 1949.

There were no observations of adult frogs by the time tadpoles were observed. Observations indicate that the algal mat probably prevents bass from catching the tadpoles and young frogs. Following the physical removal of the mat, during the summer of 1949, extreme surface agitation in the shallows near concentrations of tadpoles indicated that fish were feeding heavily upon them.

Snails were common in the pond and were very conspicuous during the summer of both years.

The pond in the spring of 1946 and 1948 contained large numbers of similar aquatic insects. Collections made on June 24, 1946 by Julian L. Dusi contained: Corixidae, Dytiscidae, Gerridae, Heliplidae, Hydrophilidae, and Notonectidae.

In the spring of 1949 the pond was almost completely lacking in insects. On February 24, 1949 enormous numbers of midges were observed emerging. They were present until March 3, 1949 after which date, probably as a result of cold weather, none were observed. Dragon flies and damsel flies were periodically common during both years of study. The damsel flies preceded the dragon flies in time of appearance. Large numbers of dragon flies were observed on June 24, 1948 and June 10, 1949, occurring after a period of almost complete absence.

Game birds and animals on the farm pond area consisted of blue-winged teal, lesser scaup, ring-necked pheasant, woodcock, dove, rabbit and raccoon.

FISH MORTALITY IN THE POND

On September 1, 1947 fish mortality occurred and a total of 168 bluegills and 11 black bass were floating on the surface. As measured by Julian L. Dusi, the 11 bass averaged 24.3 cm, and 124 of the bluegills averaged 14.7 cm in length; the remainder of the bluegills were about 4 cm long. These fish were stocked as fingerlings and fry during the fall of 1946. Records of summer fish mortality are common in the literature but generally data on dissolved oxygen or free carbon dioxide does not accompany such reports. Dissolved oxygen determinations in connection with summer fish mortality have been reported by Smith and Swingle (1938) as 0.1 ppm (2 P.M.), 3.4 ppm (9 P.M.) and 0.8 ppm (4 A.M.); Tomlinson (1935) reported barely a trace of dissolved oxygen. Smith and Swingle (1938) reported mortality occurring after excessive fertilization. Tomlinson's observations were made on a 125–150 acre "weed bottom" lake a few days after the occurrence of severe rains and an abrupt change in temperature. Roach and Wickliff (1934) also reported mortality, occurring in the presence of vegetation, after a severe wind and rain storm.

Mortality observed in the farm pond studied occurred during or shortly after a severe rain storm; this storm was accompanied by thunder and lightning. Whether or not the fish died as a result of the pond being struck by lightning or other factors is not known. An analysis of the weather conditions prior to the mortality offers a possible explanation of this summer kill.

The algal mat, as previously discussed, did not exist, although filamentous algal were present along the edges of the pond. Observations indicate that green *Oedogonium* if present on the bottom of the pond rises to the surface during periods of warm weather. Providing that these observations are applicable to other filamentous green algae, it is doubtful that filamentous green algal were present on the bottom of the pond at the time of the fish kill as the month of August was the warmest in 65 years and no free floating algae was observed. Surface water temperatures determined by Hintz and Reynolds during August were in the low thirties (° C).

A relatively high summer water level, one foot below the overflow, existed and probably was a result of the lack of an algal mat, which increases the evaporating

surface of the pond, and the presence of heavy precipitation in June followed by the lowest average temperature during July in Ohio since 1891.

The above conditions appear to be conducive to the development of "low" dissolved oxygen values as absence of filamentous green algae indicates little oxygen produced as a result of photosynthesis; high water temperatures result in greater oxygen consumption by fish and an increased threshold of survivability; warm weather is probably conducive to greater bacterial action with the subsequent reduction of oxygen; dispersal of organic material from the bottom as a result of heavy precipitation may be conducive to increased bacterial action or, as suggested by Tomlinson (1935), the washing of bacteria into a pond may indirectly be the cause of oxygen depletion.

The mixing of bottom and surface waters, as a result of heavy winds and cold rains flowing to the bottom with subsequent equalization of small amounts of dissolved oxygen throughout the pond, might possibly have resulted in dissolved oxygen being below the critical amount required for fish survival. It is conceivable that such a condition could have occurred on July 29, 1948 in the pond, as the dissolved oxygen content on the bottom was 0.1 ppm and the surface water had the lowest amount detected during the undisturbed study (April 16, 1948 to June 21, 1949). Bluegills were observed, with the exception of early morning and evening, for the first time in the surface water.

SUMMARY

1. Selected biological, physical, and chemical conditions of an Ohio farm pond were studied at weekly intervals over a sixteen month period.

2. Photosynthesis, strong winds, and heavy rains have an effect upon the dissolved oxygen content of a pond.

3. During portions of the winter relatively large amounts of dissolved oxygen occurred concurrently with "blooms" of *Chlamydomonas*.

4. An algal surface cover has a profound influence upon various physical, chemical, and biological conditions.

5. Supersaturation of dissolved oxygen occurred commonly.

6. Numerically, zooplankters were the dominant plankters during spring; phytoplankton were dominant during winter.

7. In general, rotifers were the most commonly observed plankters.

8. The kind and number of organisms in the algal surface cover had little relationship to the kind and number of net plankters.

9. Removal of the algal surface cover had an effect on certain biological, physical, and chemical conditions.

10. In general, there was a reoccurrence in 1949 of similar biological, physical, and chemical conditions observed in 1948.

11. Daily and seasonal variability occurred in various biological, physical, and chemical conditions.

12. The temperature of the surface and bottom water is influenced by air temperature.

13. In general, an extensive algal mat was accompanied by maximum light transmission.

14. An algal surface cover apparently has an effect of increasing the amount of evaporation from a pond surface.

15. A discussion of summer fish mortality is presented.

ACKNOWLEDGMENTS

This study, with the exception of the first six months, was conducted while I was a Research Fellow of The Ohio Cooperative Wildlife Research Unit. The Ohio State University, The Ohio Division of Conservation and Natural Resources,

The Fish and Wildlife Service and the Wildlife Management Institute cooperating. C. A. Dambach, E. H. Dustman, E. L. Green, D. L. Leedy, W. E. Ricker, W. R. Schlenker, H. G. Smith, T. I. Storer, C. E. Taft, J. N. Wolfe and my wife Patricia assisted on various phases of the study. Appreciation is especially expressed to Clarence E. Taft whose unselfish sacrifice of time, innumberable suggestions, and algal identifications made this study possible.

The data collected during this study are tabulated in the following: Schultz, Vincent, 1949—A limnological study of a farm pond. Dissertation, The Ohio State University, Columbus, Ohio.

LITERATURE CITED

Allen, W. E. 1930. Methods in quantitative research on marine microplankton. Bull. Scripps Inst. Oceanog., Tech. Ser. 2 (8): 319–329.

American Public Health Ass'n and American Water Works Ass'ns. 1946. Standard methods for the examination of water and sewage. 9th ed. Am. Public Health Ass'n., New York, N. Y., xvii, 286 pp.

Anderson, W. L. 1948. Results of an analysis of farm ponds in the midwest. Prog. Fish-Cult. 10: 111–116.

Birge, E. A., and **C. Juday.** 1911. The inland lakes of Wisconsin. The dissolved gases of the water and their biological significance. Bull. Wisc. Geol. and Nat. Hist. Sur., No. 22: 1–259.

Chambers, C. O. 1912. The relation of algae to dissolved oxygen and carbon dioxide, with special reference to carbonates. Missouri Bot. Garden 23: 171–207.

Ellis, M. M., B. A. Westfall, and **M. D. Ellis.** 1946. Determination of water quality. Research Report 9, U. S. Fish and Wildlife Service. 122 pp.

Fessler, F. R. 1949. A survey of fish populations in small ponds by two methods of analysis. Master's Thesis. Iowa State College.

Fritsch, F. E. 1931. Some aspects of the ecology of freshwater algae. Jour. Ecol., 19: 233–272.

Fritsch, F. E., and **Florence Rich.** 1909. Studies on the occurrence and reproduction of British freshwater algae in nature. 2. A five year's observation of the fish pond, Abbot's Leigh, near Bristol. Proc. Bristol Natur. Soc., 4th. ser II, pp. 27–54.

———. 1913. Studies on the occurrence and reproduction of British freshwater algae in nature. 3. A four year's observation of a freshwater pond. Annales de Biologie Lacustrie 6: 1–83.

Greenbank, J. 1945. Limnological conditions in ice-covered lakes, especially as related to winter-kill of fish. Ecol. Mono., 15: 343–392.

Hall, V. C. 1947. The algal periodicity of "farm pond," Ohio State University. Unpublished (Botanical Problem supervised by C. E. Taft). 6 pp.

Hutchinson, G. E. 1944. A critical examination of the supposed relationship between phytoplankton periodicity and chemical changes in lake waters. (Limnological studies in Connecticut, VII) Ecol., 25: 3–26.

Lackey, J. B. 1939. The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. U. S. Public Health Service, Pub. Health Repts., 53: 2080–2093.

Lagler, K. F. 1949. Studies in freshwater fishery biology. J. W. Edwards, Ann Arbor, Mich. v, 231 pp.

Laurie, E. M. O. 1942. The dissolved oxygen of an upland pond and its inflowing stream at Ystemtuen, North Cardiganshire, Wales. Jour. Ecol., 30: 357–382.

Littleford, R. A., C. L. Newcombe and **B. B. Shepherd.** 1940. An experimental study of certain quantitative plankton methods. Ecol., 21: 309–322.

Moore, W. G. 1942. Field studies on the oxygen requirements of certain freshwater fishes. Ecol., 23: 319–329.

Platt, E. L. 1915. The population of the "blanket algae" of freshwater pools. Am. Nat., 49: 752–762.

Rawson, D. S. 1944. The calculation of oxygen saturation values and their correction for altitude. Special Pub. No. 15, Limnological Soc. of Am. 4 pp.

Ricker, W. E. 1932. The utility of nets in freshwater plankton investigations. Trans. Am. Fish. Soc., 62: 292–303.

Roach, L. S., and **E. L. Wickliff.** 1934. Relationship of aquatic plants to oxygen supply and their bearing on fish life. Trans. Am. Fish. Soc., 64: 370–376.

Smith, E. V., and **H. S. Swingle.** 1938. The relationship between plankton production and fish production in ponds. Trans. Am. Fish. Soc., 68: 304–315.

Smith. M. W. 1934. Physical and biological conditions in heavily fertilized water. Jour. Biol. Bd. Canada, 1: 67–93.

Surber, T., and **T. A. Olson.** 1936. Some observations on Minnesota fish ponds. Trans. Am. Fish. Soc., 66: 104–127.

Taft, C. E. 1949. The algologists' part in city and industrial water supply problems. Limnological Aspects of Water Supply and Waste Disposal. (Published by Am. Ass'n. Adv. Sci.) pp. 74–78.
Tiffany, L. H., and **E. N. Transeau.** 1927. *Oedogonium* periodicity in the North Central States. Trans. Am. Micro. Soc., 46: 166–174.
Tomlinson, D. 1935. Rare aquatic phenomena. Science, 82: 418.
Ward, E. B. 1940. A seasonal population study of pond Entomostraca in the Cincinnati region. Amer. Midl. Nat., 23: 635–691.
Welch, P. S. 1948. Limnological methods. The Blakiston Co., Philadelphia, Penn. xviii, 381 pp.
Whitney, R. J. 1942. Diurnal fluctuations of oxygen and pH in two small ponds and a stream. Jour. Exp. Biol., 19: 92–99.
Wiebe, A. H. 1929. The effects of various fertilizers on plankton production. Trans. Am. Fish. Soc., 59: 94–105.
———. 1930. Investigations on plankton production in fish ponds. Bull. U. S. Bur. Fisheries (Doc. 1082) 46: 137–176.
———. 1934. Nocturnal depression in the dissolved oxygen in fish ponds with special reference to an excess of coarse vegetation and fertilizers. Trans. Am. Fish. Soc., 64: 181–188.
Woodbury, L. A. 1941. A sudden mortality of fishes accompanying supersaturation of oxygen in Lake Waubesa, Wisconsin. Trans. Am. Fish. Soc., 71: 112–117.

Evolution. *A. Franklin Shull.* McGraw-Hill Book Co., New York. Second edition, 1951. ix+322 pp. $5.00.

Dr. Shull has arranged the diversified phases of evolution in a terse and appealing manner. The philosophies and scientific findings of centuries, contributing to a meaningful synthesis of ideas, are presented in logical résumé.

Chapters II and III show that orderliness in diversities as well as similarities in divergent organisms imply kinship among organisms. Time and place of origins of species related to geographical conditions of their continents show that organisms evolved not merely on, but with planet Earth and its topography. Direct fossil evidence, including hominids, is discussed in an effective survey. Chapters IV, V and VI thus review the varying life on earth from precambrian Proterozoic to modern living man.

Both organic permanence and organic change conform to the dictates of mechanisms of heredity. Gradual variations through mutation, recombination and ploidy are basic factors of evolution. Their causes are listed. Their directives are observed in phenomena, such as the flexible adaptations to needs in geographical isolation, in animal societies, and in subtle human relationships (Chapters VII–XIV). The final chapter discusses the origin of life. Progress in bridging chemistry and biology of Evolution is being made.

This second edition is a terse expression of the essential points fundamental to Organic Evolution. Dr. Shull has placed proper emphasis on the genetic character of organisms for without this it would be difficult to understand the nature of the process of evolution.

G. J. Siemens

Functional Mammalian Anatomy (With Special Reference to the Cat). *W. T. Taylor* and *R. J. Weber.* D. Van Nostrand Company, New York. First edition, 1951. xi+575 pp. $7.25.

Doctors Taylor and Weber have succeeded in making a direct approach to mammalian anatomy. Their emphasis on the functional aspects tends to vitalize the subject. The introduction includes a clear explanation of the cellular nature of tissues. Mammalian organs and organ systems are simply yet fully discussed in essential scientific language. Illustrations by Thomas Courtney Lee are mostly realistic, often in color. Generally, they are true and accurate representations of cat anatomy. Some are schematic, illustrative of mammals in general.

All organs and systems, such as the integumentary, skeletal, muscular, nervous, circulatory, respiratory, digestive, urinary, and reproductive, as well as the special sense organs, are systematically, vividly and boldly described. The lymphatic and the endocrine systems are presented likewise from the viewpoint of functional anatomy. Terminology, as found in earlier books on anatomy, appears to have undergone research eliminating the obsolete, retaining and introducing pertinent, effective, scientific terms, easy to understand yet scholarly, and stimulating the study of languages which has become indispensable in this field.

The cat is the representative organism used throughout. All interpretations are with reference to this mammal, which, due to its homology with man, closely approaches human anatomy and bodily functions. A forty page manual for the regional dissection of the cat makes this book highly commendable as a text and also as a laboratory guide for cat dissection.

G. J. Siemens

FACTS OR FICTION: CHERMES ALNI L. (PSYLLIIDAE)

JOHN S. CALDWELL
Circleville, Ohio

It is not desirable to begin an episode similar to the historic squabble of "Mr. Kirkaldy, Mr. Distant," never-the-less after the exceptionally prompt and misleading reply to my short article (Caldwell, 1946), it is necessary to correct the false impression conveyed by Russell (1946).

Russell falsely states that I have taken the identity of *alni* L. entirely from the Kalm reference when on the contrary *alni* L. is determined entirely from the original description in the tenth edition of *Systema Naturae*. Realizing that insects are living organisms fitting into a definite niche in their environment and that they do not spring into being glued to a point nor occur normally under cover-glass, I have pointed out that the biological data in the Kalm reference checks perfectly with the statements in the original description thereby proving that the insect with the "*caudis plumosis* . . ." occurring on "*Betulae Alni* . . ." in "America *septentrionali*," is the one now determined as *Prociphilus tessellatus* (Fitch) = *Chermes alni* L.

After the rise and fall of several dictators, the lay world has realized that if a lie is told often enough it soon is accepted as the truth. This unfortunately has been the case with the statement that *alni* L. can not be determined from the original description and the scientific (?) world accepts this fiction as fact. The truth is that any normal child of 12 can, by following the limitations imposed by the original description, collect and thus identify this insect anytime in season. The trouble has been, absurd as it may seem, that the closet naturalists, and especially those in America *septentrionali*, have never ventured into the great out-of-doors to observe what goes on in nature but instead have trained their bifocles on the Latin phrase "*caudis plumosis tectae*" and emphatically declared that *alni* L. can not be identified from three words.

Article 25 very foolishly erects about five possibilities for the support of a valid name and makes no reservation in case two or more occur at the same time. *Alni* L. will include about four possibilities; however, if one were to use a little common sense or some resemblence of logic, one would believe that the original description should have preference over all citations. When we let the "monster" called nomenclature create biological impossibilities as it has in the past with *alni* L., then it is high time to part company with the monster and stick to biological facts which are the truth, "novel" as the idea may seem.

REFERENCES

Caldwell, J. S. 1946. Chermes alni, two centuries after Kalm. Ohio Jour. Sci., 46: 71–72.
Russell, L. M. 1946. The identity of Chermes alni Linne. Proc. Ent. Soc. Wash., 48: 249–250.

BACK NUMBERS

Almost all back numbers and volumes of the OHIO NATURALIST and the OHIO JOURNAL OF SCIENCE are available. They may be purchased from the Business Manager at $4.00 per volume or $1.00 per number (postage extra outside U. S. A.).

THE HOUSEFLY (*MUSCA DOMESTICA* LINN.), AS A VECTOR OF *SALMONELLA PULLORUM* (RETTEGER) BERGY, THE AGENT OF WHITE DIARRHEA OF CHICKENS[1]

JOHN B. GERBERICH

Department of Biology, University of Minnesota, Duluth Branch, Duluth 5

For many years flies have been suspected of being one of civilization's worst enemies in the transportation of bacterial organisms. Numerous publications (for historical account refer to Steinhaus, 1946) have appeared furnishing evidence that the adult housefly is a mechanical carrier of bacteria which are not only harmful to man but also to his domestic animals. Fewer studies are found relative to another phase of flies as vectors: that is, the fate of bacteria ingested by the larvae in relation to metamorphosis and the duration of the association. No study, to date has been found concerning the bacteria-fly-chicken association of white diarrhea.

The fact that maggots will grow and develop best in habitats rich with bacteria and yeast is commonly accepted. If the breeding habitats and the feeding habitats of the housefly are studied, one learns that the food and fecal matter of chickens are often utilized by the housefly for breeding and for food. Observations of chicken behavior indicates that they continually capture and devour many flying insects. The possibility, therefore, seems to exist that if the larvae while feeding can be infected with a chicken pathogen and if these bacteria can endure the metamorphosis of the host, there is a direct relationship between the agent of a chicken disease and the flight range of the adult fly.

The organism selected for study was *Salmonella pullorum* (Retteger) Bergey, causative agent of white diarrhea of chickens. The importance of this disease to the poultry industry is summarized in U. S. D. A. Farmers' Bulletin No. 1652, p. 7: "Pullorum disease (bacillary white diarrhea) is quite wide spread, existing in every section of the United States where appreciable numbers of poultry are kept. It causes heavy financial losses, resulting from the deaths of baby chicks, diminishing egg production in hens and pullets, reduces hatchability of eggs, and occasionally the death of hens due to generalized pullorum infection." Young chicks up to three weeks seemed to be most vunerable. Death rate in infected chick broods may range from 50 to 80 percent.

METHOD

Bacterial-survival Study

To arrive at the subsequent conclusions 15 to 20 newly hatched housefly maggots were placed upon a 48-hour-old pure culture of the test bacterium which was growing on nutrient agar in Petri-dishes. The Petri-dishes were kept at a temperature of 37° C. It was observed that the Petri-dishes would fuse together and seal off the supply of air unless they were opened daily.

After the larvae developed and pupated, the pupae were sterilized in an aqueous solution of 1: 1000 mercuric chloride (Glaser, 1923) for five minutes. While in the germicidal solution, the pupae were agitated. This disposed of the air bubbles adhering to the pupae and usually caused them to sink. At the conclusion of the five minute period, each pupa was transferred to a tube of nutrient broth and agitated for five minutes. Then the pupa was washed in sterile-distilled water and placed on a sterile agar plate to await fly emergence. Each pupa received a

[1]Part of a dissertation submitted in partial fulfillment for the Ph.D. degree, Department of Zoology and Entomology, Ohio State University, Columbus.

THE OHIO JOURNAL OF SCIENCE 52(5): 287, September, 1952.

number in the order of its processing and this number remained with the specimen throughout the experiment. Controls were maintained throughout the experiment.

The flies were placed in the following indicative categories: the positive or negative effectiveness of the germicide, the survival of the fly, and the presence of bacterial growth after the fly emerged. If the pupa was free of any evidence of contamination but did not emerge, it was classified under "dead" but, carrying the same identification, was macerated. Those pupae that were free of contamination and that emerged and showed evidence of disseminating bacteria were used in bacterial-survival phase. If any of the experimental flies did not produce evidence of harboring bacterial organisms, they were transferred and macerated along with the dead pupae.

After the flies emerged, the agar plates were observed for bacterial growth. Whenever bacterial growth appeared on any plate, the fly was washed for five minutes in an aqueous solution of 1: 1000 mercuric chloride, passed through the broth tube checks, rinsed in sterile, distilled water and transferred to either the bacterial-fly longevity association or the bacteria-fly-chicken association. The plates which held the emerged flies were incubated for 24 hours and at the end of the incubation period a letter of the alphabet was assigned to each bacterial colony and they were examined for the presence of the test organism. The bacteria were identified according to Bergey (1939) and Breed, Murray, and Hitchens (1948). Organisms which did not meet the key characteristics for the test bacterium remained unidentified. Only the experimental bacterium was recorded in the data.

The experimental flies which emerged and did not show any evidence of bacterial growth, and the pupae which did not emerge but were free of contamination, were externally sterilized in an aqueous solution of 1: 500 mercuric chloride for ten minutes. Each specimen was passed through the nutrient broth check and placed in a sterile, distilled water blank in which it was macerated with sterile needles. The macerated substances were agitated so as to disperse the material evenly within the water blank and then streaked upon sterile agar plates. The plates were incubated for 48 hours, and if colonies appeared they were identified for *Salmonella pullorum*.

The flies which emerged and showed positive evidence of carrying the test organisms were divided into groups. These groups were arranged and handled to permit study of (1) how long the bacterial organism remained with the housefly and during what part of this period it was disseminated, (2) whether the infected housefly, when devoured by a host, sufficiently transferred the test organism to the chicken.

Existence of Bacteria within the Housefly

A portion of the flies that showed positive evidence of carrying the test species through their metamorphosis, was studied to determine the longevity of the bacteria within the housefly and during what part of this period the bacteria were disseminated. Flasks plugged with cotton and autoclaved for one hour at 250° C. were filled to a depth of two inches with sterile nutrient agar and after solidification of the medium, the flasks were tilted to collect the moisture of condensation. The surplus moisture was poured out and then the flasks were ready for the flies. As soon as the bacterium had been recovered from the housefly in the survival phase, the fly was sterilized in an aqueous solution of 1: 1000 mercuric chloride for five minutes, then passed through the nutrient broth check, rinsed in sterile, distilled-water and transferred to a 500 cubic centimeter filter flask which had been previously sterilized and contained two inches of sterile agar. The flies that showed contamination by bacterial growth in the broth tubes were eliminated for the present but were successively sterilized until free of contamination or discarded.

After the fly had been placed in a flask, observations were made frequently for bacterial growth. Whenever growth appeared, the fly was sterilized and

transferred to a second sterile flask and the bacterial colonies of the first flask were identified.

Every second day a sterile piece of cotton which had been soaked with boiling simple syrup (10 parts water and one part sugar) was hung from the cotton stopper for three to six hours. This constituted food for the fly.

As soon as it was apparent that the fly was dying or it was found dead, it was sterilized in an aqueous solution of 1: 500 mercuric chloride for ten minutes, passed through the nutrient broth check, rinsed and macerated. The different colonies growing from the streaked macerated material were identified and recorded.

Bacteria-fly-chicken Association

A certain portion of the flies which had produced evidence of carrying a test bacterium were studied to determine the bacteria-fly-chicken association. They were sterilized in an aqueous solution of 1: 1000 mercuric chloride for five minutes, passed through the nutrient broth tubes and rinsed in sterile, distilled water. Until the effectiveness of the germicide could be observed each fly was stored in a sterile Florence flask, the bottom of which was covered with one inch of agar. After no contamination was evident, the flies were placed in cubicles with chickens.

Chickens of the most susceptible age to *S. pullorum* were secured from a hatchery which guaranteed that they were free of the organism under consideration. The chickens were placed in separate cubicles and on two consecutive days before the flies were introduced, fresh fecal matter from the chickens was examined to guarantee the absence of the test bacterium. The cubicles were cleaned each day by removing the inner liners which caught the fecal matter and other debris. As soon as the experimental flies, which had been placed with these chickens had been consumed, the chickens were fed commercial feed as recommended by the hatchery. Distilled water was available for the chickens and they were kept at room temperature.

After the flies had been introduced, fecal examinations were made every 24 hours until the chicken excrement showed positive evidence of *S. pullorum* and when it was recovered for three days in succession the chicken was discarded with the assumption that the chicken had obtained the bacterium from the flies placed in the cubicles with it. No attempt was made to study the effects of the test bacterium on the chickens.

SUMMARY OF DATA

Five hundred pupae were treated as described under the method for the study of *S. pullorum* surviving the matamorphosis of the housefly. Of the 500 pupae, 301 emerged free of contamination, 135 were discarded because of contamination and 64, free from contamination, did not emerge and were assumed to be dead.

One hundred and twenty-two of the 301 emerged flies, which were free of contamination, gave evidence of carrying *S. pullorum* through the pupal stage by disseminating the test organism on sterile agar. One hundred and seventy-nine revealed no trace of the experimental bacterium and were macerated.

The pupae which were free of contamination but did not emerge and the flies that did not disseminate test bacterium were macerated in the previously described manner. Thirty-one of the 64 pupae macerated and 28 of the 179 flies macerated harbored *S. pullorum*.

The test bacterium was harbored by 181 out of 365 pupae free of contamination. One hundred and twenty-two of the 301 emerged flies disseminated *S. pullorum*.

Thirty flies which previously had disseminated *S. pullorum* were treated for the study of the longevity of the bacteria-fly-association. One of the 30 flies survived 23 days. The test bacterium was last disseminated by this fly on the fifteenth day. The bacterium was not recovered again from the above mentioned fly, although *S. pullorum* was recovered from another fly on the twenty-second day when it was

macerated. This fly survived 22 days and last disseminated *S. pullorum* on the second day. The third longest period of fly longevity was 20 days. The test bacterium was recovered from this third fly upon maceration on the twentieth day but it had not disseminated *S. pullorum* since the ninth day. The test bacterium was disseminated by 26 flies of which 25 produced no evidence after nine days, but the test bacterium was recovered from the macerated material of one fly after 22 days.

Thirty-seven flies which had previously disseminated *S. pullorum* were treated for the study of the bacteria-fly-chicken association. Thirty-one chickens were allowed to feed on 37 previously infected houseflies. Four chickens, though treated similarly to the others, were separated from all flies and used as controls.

Five chickens produced evidence of *S. pullorum* from their fecal matter two days after the flies had been introduced into the cage but only one of the five produced such evidence for three consecutive days. The greatest recovery of *S. pullorum* was on the fifth day. Variance in production of the test bacterium was from 2 to 10 days. All 31 experimental chickens produced *S. pullorum* three consecutive days in their fecal matter. Evidence from this data indicates that flies do carry the test bacterium and that *S. pullorum* does develop sufficiently within the chickens to be recovered from the chickens' excrement.

CONCLUSIONS

The data reveal that *S. pullorum* was disseminated by 40.53 percent of the experimental flies, 49.58 percent of the pupae harbored the test bacterium. The experimental bacterium was disseminated for fifteen days and harbored for 22 days. Four of the 30 test flies used in the longevity association study produced *S. pullorum* after the ninth day. All of the 30 flies gave evidence prior to the ninth day of containing the test bacterium. *Salmonella pullorum* was recovered from the macerated material of 70 percent of the experimental flies at death.

Thirty-seven infected flies were fed to 31 three week old chickens and in two days the test bacterium was recovered from the chickens' excrement. All 31 chickens produced *S. pullorum* in their fecal matter within ten days. In this study, *S. pullorum* was ingested by the larva of the housefly (maggot), survived the metamorphosis of the housefly and sufficiently established itself in the chicken, by a vector (the housefly), to be recovered from the chickens' feces. The above data establish the housefly, *Musca domestica*, as a vector of *S. pullorum* and thus increases the potential area of bacterial dissemination to that of the range of flight of the housefly.

I am indebted to Dr. C. E. Venard, Department of Zoology and Entomology and Dr. H. H. Weiser, Department of Bacteriology, both of The Ohio State University, for their suggestions and criticisms pertaining to this study.

LITERATURE CITED

Bergey, D. H., R. S. Breed, E. G. Murray, and **A. P. Hitchens.** 1939. Bergy's Manual of Determinative Bacteriology. 5th Ed. 1032 pp. Williams and Wilkins Co. Baltimore.

Breed, R. S., E. G. Murray, A. P. Hitchens. 1948. Bergy's Manual Determinative Bacteriology. 6th Ed. 1529 pp. Williams and Wilkins Co. Baltimore.

Gerberich, J. B. 1948. Rearing houseflies on common bacteriological media. Jour. Econ. Ent., 41(1): 125.

Gerberich, J. B. 1951. Transmission of bacteria through the metamorphosis of the housefly and the longevity of such an association. Ph.D. Dissertation. 82 pp. Ohio State University, Columbus 10.

Gerberich, J. B. 1951. Passing of *Staphylococcus aureus* Rosenbach through the metamorphosis of the housefly. Proc. Minn. Acad. Sci., 16: 35.

Glaser, R. W. 1923. The survival of bacteria in the pupal and adult stages of flies. Amer. Jour. Hyg., 3(4): 469–490.

Steinhaus, E. A. 1946. Insect Microbiology. 763 pp. Comstock Publishing Company, Inc. Ithaca.

U. S. Dept. of Agriculture. 1939. Diseases and parasites of poultry. Farmer's Bull. No. 1652. 67 pp.

MOSSES OF A NORTHERN OHIO AREA

MAURICE B. WALTERS

14,556 Superior Road, Cleveland Heights 18, Ohio

For some time past the writer has been endeavoring to build up as complete a list of mosses as possible in a certain limited area in the vicinity of Cleveland, Ohio. This area is known as the North Chagrin Reservation of the Cleveland Metropolitan Park System and comprises some sixteen hundred acres, of which roughly two thirds are wooded and the remainder more or less open meadows. There are two small ponds on the area and the Chagrin River borders it for some distance along one side, resulting in various marshy spots, alder thickets, button-bush bogs and so on.

The wooded part of the area consists largely of a beech-maple forest with considerable hemlock mixed in along the spurs and ravines which lead down from the higher level to the open meadows along the river. A full description of a part of this forest is to be found in a paper by Williams (1936).

The list has now reached a total of ninety-nine, including five varieties, and has nearly come to a standstill. One hundred species in a county has been said to be a near average (Conard, 1944), so that the present list from a tract which is less than one two hundredth the size of the average Ohio county may serve to point out its unusual richness.

The majority of the mosses which make up the list have been found within the confines of the forest itself. Many of these grow on decaying organic matter such as rotted logs, old stumps, or the humus of the forest floor. A number of others were found along the grassy borders of the roads and paths through the park, and on the more or less exposed soil of the cuts and embankments. Some were collected from the bark of living trees. Though the list of these is as yet small it should be materially increased. A few came from rocks in or near watercourses and one or two came from the actual streams.

The open fields and meadows yielded a good percentage, but this is another habitat the study of which is by no means completed. A few species were gathered from the shores of the ponds, including two species of Sphagnum judged to be among the most common. But due to the number and complexity of the Peat Mosses, the difficulty of working with them and the fact that complete keys and descriptions of them are not readily available, nothing further has been attempted here. In any event the number of species of Sphagnum which might be encountered in the very small areas to which they are confined cannot be much larger.

Should the reader desire fuller details on the climate, geology and other features of the area he is referred to the paper by Williams (1936).

Specimens of all the species in the following list are in the writer's herbarium in Cleveland. The order of listing is in accordance with the Checklist of Mosses for North America as issued by the American Bryological Society (then the Sullivant Moss Society) (Grout, 1940).

Most of the identifications, including all which were in the slightest doubt, have either been made or confirmed by Dr. Henry S. Conard, to whom the writer owes his deepest thanks for his very great help and encouragement. Others were made by Dr. Richard T. Wareham, and one Fissidens new to North America was identified and described by Dr. William C. Steere, to both of whom the writer makes grateful acknowledgment.

SPHAGNACEAE

Sphagnum Girgensohnii Russow. On boggy ground around the borders of one of the ponds of the area.

Sphagnum Magellanicum Brid. Same habitat as the preceding. These two Sphagnums are probably the common ones of the area, although there are undoubtedly others.

TETRAPHIDACEAE

Tetraphis pellucida Hedw. Usually found on decayed wood. Occ.—General throughout the woods.

POLYTRICHACEAE

Atrichum angustatum (Brid.) Bry. Eur. On soil, especially along the borders of the paths and boulevards through the woods. Occ.—Common and widespread.

Atrichum angustatum (Brid.) Bry. Eur. var. *plurilamellatum* (Jennings) Frye. On soil in the woods. Occ.—Less common than the species.

Atrichum undulatum (Hedw.) Beauv. Usually on rather wet clayey soil. Occ.—Common.

Atrichum undulatum (Hedw.) Beauv. var. *altecristatum* Ren. & Card. As to frequency of occurrence, no careful check has been attempted on the area as yet.

Pogonatum pensilvanicum (Hedw.) Paris. On bare soil. Occ.—Common.

Polytrichum commune Hedw. In open spots in the woods and in the meadows. Occ.—Very common.

Polytrichum juniperinum Hedw. In dry open places in the woods. Occ.—Fairly frequent.

Polytrichum ohioense Ren. & Card. Similar in situation to *P. commune* but less frequent in occurrence.

Polytrichum piliferum Hedw. On the ground in dry open places. Rare.

FISSIDENTACEAE

Fissidens bryoides Hedw. On rather low wet bare ground. Infrequent.

Fissidens Bushii Card. & Ther. On bare wet ground. Frequent.

Fissidens exilis Hedw. On bare patches of ground in the woods. The green stain of the protonema will often lead to its discovery, otherwise it is almost impossible to detect it if it is not in fruit. Infrequent. First record for North America. See *The Bryologist*, Vol. 50, pp. 131–136.

Fissidens minutulus Sull. On rocks, usually sandstone, in open ravines, bridge foundations, etc. Rather common.

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. In dry open places such as the borders of the park boulevards. Very common.

Ditrichum lineare (Sw.) Lindb. On moist ground in open places. Rather infrequent.

Ditrichum pallidum (Hedw.) Hampe. In dry open places. Fairly frequent.

DICRANACEAE

Dicranella heteromalla (Hedw.) Schimp. On soil everywhere in the woods. One of the commonest mosses of the area.

Dicranella heteromalla (Hedw.) Schimp. var. *orthocarpa* (Hedw.) Paris. Uncommon.

Dicranella varia (Hedw.) Schimp. On moist clayey soil. Infrequent.

Dicranum Bonjeani DeNot. The only specimens of this which were collected check perfectly with the variety *alatum* Barnes, according to Dr. H. S. Conard. This variety is apparently not given rank as such by Grout in the Moss Flora of North America, nor included in the Checklist. However, the specimens on which this listing are based are definitely not the typical *D. Bonjeani*, a frequenter of marshy ground. (Syn.—*D. palustre*.) Collected only once, on dry soil under white pines and some mixed hardwood.

Dicranum fulvum Hook. On rocks in the forest, occasionally on stumps. Fairly common.

Dicranum montanum Hedw. On the bark of trees, living or dead. Common.

Dicranum rugosum (Hoffm.) Brid. On soil in low wet places, occasionally in large mats. Infrequent.

Dicranum scoparium Hedw. On soil in the woods. Fairly common.

LEUCOBRYACEAE

Leucobryum glaucum (Hedw.) Schimp. On soil or over rocks. Very common.

BUXBAUMIACEAE

Buxbaumia aphylla Hedw. Found once only in an old road cut. It may not be rare but is difficult to find, being visible only when in fruit.

POTTIACEAE

Astomum Muhlenbergianum (Sw.) Grout. On soil. Another pygmy moss easily overlooked. Found only twice.

Barbula fallax Hedw. Usually on bare or recently disturbed soil. Fairly common.

Barbula unguiculata Hedw. On bare disturbed earth, especially earth slides along roads and trails. Very common in these places.

Desmotodon obtusifolius (Schw.) Jur. On sandstone rock. Uncommon.

Pottia truncata (Hedw.) Fürnr. On bare ground. Infrequent.

Weisia viridula Hedw. On bare ground. Fairly frequent.

EPHEMERACEAE

Nanomitrium Austinii (Sull.) Lindb. On mudflat of a pond, exposed by low water. Found only once.

DISCELIACEAE

Discelium nudum (Dicks.) Brid. On bare alluvial soil. Found in successive years in one spot only. Visible only when fruiting, except for the protonema which soon disappears. Grout lists only four collections of this species in MFNA.

FUNARIACEAE

Funaria hygrometrica Hedw. Usually on bare, often gravelly soil in open places. Fairly common.

Physcomitrium immersum Sull. Similar in its occurrence to *Nanomitrium Austinii*, and in fact the two were found together in their only known occurrence on the area.

Physcomitrium turbinatum (Mx.) Brid. On bare earth. Quite common.

ORTHOTRICHACEAE

Orthotrichum pumilum Dicks. On bark of trees. Uncommon.

AULACOMNIACEAE

Aulacomnium palustre (Web. & Mohr) Schw. On soil in low swampy spots. Common and widespread.

BRYACEAE

Bryum argenteum L. In crevices in the stonework of bridges, on the sides of roadbeds where it is often mixed with *Ceratodon*, and in other dry exposed situations. Common.

Bryum caespiticium (L.) Hedw. Found in situations much like those of the preceding, and of about equal frequency of occurrence.

Bryum capillare (L.) Hedw. On the bark of trees or on moist soil. Uncommon.

Bryum pseudotriquetum (Hedw.) Schw. In wet situations. Apparently quite infrequent, though rated a common species.

Leptobryum pyriforme (Hedw.) Schimp. On shaly cliffs, moist logs, etc. Rather uncommon.

Pohlia nutans (Schreb.) Lindb. On moist ground and bases of trees. Very common.

Pohlia pulchella (Hedw.) Lindb. On moist alluvial soil. Rare.

Pohlia Wahlenbergii (Web. & Mohr) Andrews. In wet open places. Rather infrequent.

MNIACEAE

Mnium affine Bland. On wet ground in the woods. Very common.

Mnium cuspidatum Hedw. On wet ground and decayed wood in the forest. Very common and widespread.

Mnium punctatum Hedw. In similar situations to the preceding but rather less common.

Mnium punctatum Hedw. var. *elatum* Schimp. In wet places, on shaly ravine banks, etc. Infrequent.

Mnium stellare Hedw. On base of elm in ravine. Found once.

HYPNACEAE

Amblystegium Juratzkanum Schimp. On decayed logs or soil in the forest. Common.

Amblystegium serpens (Hedw.) Bry. Eur. On decayed wood as a rule. Somewhat less common than the preceding.

Amblystegium varium (Hedw.) Lindb. On soil, rockwork of culverts, etc., where moist conditions prevail. Infrequent.

Brachythecium oxycladon (Brid.) J. & S. On grassy slopes in the open. Probably common, though infrequently recorded so far.

Brachythecium flagellare Bry. Eur. In rather wet places in the woods, on ground, over tree trunks, rocks, etc. Fairly common.

Brachythecium rivulare Bry. Eur. On moist ground or in water. Infrequent.

Brachythecium rutabulum (Hed.) Bry. Eur. Similar in situation and frequency to the preceding.

Brotherella recurvans (Mx.) Fleisch. In moist places in the forest, usually on decaying logs. Common.

Brotherella tenuirostris (Sch.) Broth. On tree bases or decayed wood in moist situations. Infrequent.

Bryhnia novae-angliae (Sull. & Lesq.) Grout. Usually on the ground, sometimes over rocks, in wet places. Common.

Calliergon cordifolium (Hedw.) Kindb. Around bases of cattails and rushes along the borders of ponds. Fairly common.

Calliergonella Schreberi (Bry. Eur.) Grout. On the ground in moist open areas. Fairly frequent.

Campylium chrysophyllum (Brid.) Bryhn. In moist places on the ground. Very common.

Campylium hispidulum (Brid.) Mitt. On humus in the woods. Found once.

Chamberlainia acuminata (Hedw.) Grout. On logs, soil, etc., in the ravines and other moist places. Fairly common.

Cirriphyllum Boscii (Schw.) Grout. On the ground in meadows and along the woods borders. Common.

Climacium americanum Brid. On soil in low wet places. Fairly common.

Climacium Kindbergii (R. & C.) Grout. In low wet places. Common.

Entodon seductrix (Hedw.) C. Muell. On soil, decaying wood, rockwork of culverts, etc. Infrequent.

Eurhynchium hyans (Hedw.) J. & S. On moist ground in the woods or along the borders. Fairly common.

Eurhynchium rusciforme (Neck.) Milde. On rock bottom of watercourse. Found once.

Eurynchium serrulatum (Hedw.) Jindb. On soil in the woods. Common.

Heterophyllum Haldanianum (Grev.) Kindb. On soil or decayed wood in the forest. Very common and widespread.

Hygroamblystegium irriguum (Wils.) Loeske. On soil or rocks in quite wet situations. Infrequent.

Hypnum curvifolium Hedw. On moist ground in woods. Infrequent.

Hypnum imponens Hedw. On decaying logs in moist ravines. Infrequent.

Hypnum molluscum Hedw. On moist soil or bases of trees. Infrequent.

Hypnum Patientiae Lindb. On wet ground, margins of ponds, along streams through meadows. Common.

Hypnum reptile Mx. On decayed wood and bases of trees in the forest. Fairly common.

Leptodictyum riparium (Hedw.) Warnst. On decayed wood in wet situations. Rather common.

Leptodictyum trichopodium (Schultz) Warnst. In situation similar to the preceding, probably more common.

Plagiothecium denticulatum (Hedw.) Bry. Eur. On moist soil and decayed wood in the forest. Common. The forma *propagulifera* Ruthe has also been collected frequently.

Plagiothecium elegans (Hook.) Sull. On the base of a beech tree in a rather moist spot. Collected only once. Since this was apparently the first record of this species for Ohio it was sent to Dr. Richard T. Wareham, Newton Lower Falls, Mass., for recheck. He confirmed the identification.

Plagiothecium Roeseanum (Hampe) Bry. Eur. On moist soil and decayed wood. Fairly common.

Plagiothecium turfaceum (Lindb.) Lindb. On decaying hemlock stump. Found only once. (Det. by Dr. Wareham.)

Platygyrium repens (Brid.) Bry. Eur. On bark of trees and logs. Very common.

Sematophyllum adnatum (Mx.) E. G. B. On bark at bases of trees. Infrequent.

LESKEACEAE

Anomodon attenuatus (Hedw.) Hüben. On bases of trees. Infrequent.

Anomodon rostratus (Hedw.) Schimp. On bases of trees in moist places. Infrequent.

Helodium paludosum (Sull.) Aust. On the ground in marshy places. Common.

Thuidium delicatulum (Hedw.) Mitt. On soil and decayed wood in the forest and along the grassy road borders. Common.

Thuidium recognitum (Hedw.) Lindb. Similar in situation and frequency to the preceding, may be mixed with it.

Thuidium virginianum (Brid.) Lindb. On trunk of fallen white ash. Found only once.

FONTINALACEAE

Fontinalis novae-angliae Sull. In running streams, not necessarily flowing the year round. Infrequent.

REFERENCES

Conard, H. S. 1944. How to Know the Mosses. Wm. C. Brown Co., Dubuque, Iowa.

Grout, A. J. 1903. Mosses with Hand-lens and Microscope. Published by the author. New York City.

Grout, A. J. 1928–1940. Moss Flora of North America. 3 vols. Published by the author. Newfane, Vt.

Grout, A. J. 1940. List of Mosses of North America North of Mexico. The Bryologist, 43: 117–132.

Williams, A. B. 1936. The Composition of Dynamics of a Beech-Maple Climax Community. Ecol. Monographs, 6: 317–408.

Spinoza Dictionary. *Dagobert D. Runes*, Ed. Foreword by Albert Einstein. Philosophical Library, New York. 1951. xiv+309 pp. $5.00.

The editor quotes, in English translation, all of the important passages from the extant Latin and Dutch writings of Spinoza (1632–1677). This greatest of modern Jewish philosophers organized his main work, the *Ethics*, in geometrical form, with axioms, definitions, theorems, and corollaries, all integrated as in Euclid. He thought that this gave it logical rigor. Perhaps so; but this also made it difficult to study. Dr. Runes in reorganizing the work in alphabetical form, has produced a good handbook and one that is easier to study. It could be improved by a table of contents listing all of the topics which would help a beginner to decide what to read first. In the reviewer's opinion the book would be better if the topics were arranged logically according to the relations of the ideas, rather than alphabetically.

All of the comments are in a Foreword and an Introduction by Dr. Einstein and Dr. Runes, who hold correctly that Spinoza had a great soul and an important message, in spite of serious errors.

Spinoza rejected Judaeo-Christian orthodoxy and tried to interpret the universe scientifically, which, in the seventeenth century, meant mathematically. His mathematical religion and ethics are sometimes hardly recognizable as religion and ethics. However, this volume reveals his genuine saintliness.

GARDNER WILLIAMS

STRUCTURAL FEATURES OF COCKROACH EGG CAPSULES. II. THE OOTHECA OF CARIBLATTA LUTEA LUTEA (ORTHOPTERA: BLATTIDAE)[1]

FRED A. LAWSON

Department of Zoology and Entomology, The University of Tennessee, Knoxville 16

In a previous paper (Lawson, 1951), the oothecae of six species of cockroach were described. In this paper the ootheca of the small yellow cockroach, *Cariblatta lutea lutea* S and Z,[2] is described. This species, along with two others the egg capsules of which are to be described later, were taken on a collecting trip out of Tampa, Florida, in December, 1949.

Cariblatta lutea, as indicated by Blatchley (1920), is probably the smallest of the native North American roaches; of the two varieties, *C. lutea minima* Hebard is reported to be slightly smaller than the one under study here. A large series of collected and reared adult specimens of *C. lutea lutea* averaged only 10 mm in length; egg capsules are of correspondingly small size, averaging about 3 mm in length and 1.5 mm in depth. The female carries the capsule through a very brief period following its completion, after which she abandons it in some almost microscopic hiding place.

EXTERNAL

Side view. The egg capsule is somewhat boat-shaped when viewed from the side (fig. 1); the seam occupies the dorsal margin while the ventral is filled with the caudal ends of the eggs. The seam is slightly but continuously curved over the entire dorsal line, extending as a more sharply curved arc on each end. The curvature of the end profiles is different on the opposite ends; that of the distal end (i.e., that first formed), is compound, with a short, sharp arc from the seam termination merging with a slightly developed reverse-sigmoid curve that leads into the short ventral margin of the ootheca. The proximal end presents an evenly rounded profile which curves continuously and rather sharply into the lower capsule margin. The lower margin of this ootheca is very slightly concave and only about half as long as the upper. Due to the natural inequalities in the curvature of the two ends, the lower margin is slightly off-center as related to the upper outline.

The number and position of the enclosed eggs are indicated by thin lines extending around the sides from the seam base to the lower capsule margin (fig. 2); these are found to have the shape of the letter Y, with an extremely long stem below very short arms. The space between stems and *outside* the arms indicates an egg on the near side of the capsule; that enclosed *between* the arms of each Y represents the sub-seam mesal extensions of eggs of the opposite half of the capsule. This crossing-under characteristic was found also in the capsules of the German, Brown Banded, and Pennsylvania Wood roaches. Each end of the ootheca is occupied by one egg which is unpaired except for its counterpart; the remaining ova are paired but are spaced in slightly off-set positions.

The upper third of the side-wall surfaces of each egg case is marked by minute, evenly spaced horizontal ridges which duplicate the seam base curvature (fig. 3); they extend the entire length of the capsule sides and around a slight lateral portion of each end. The ridges become gradually less prominent near the middle of the side walls and are wanting on the lower third.

---

[1]Department contribution No. 49.

[2]Determined by Dr. J. J. Friauff, Vanderbilt University, Nashville, Tenn.

The Ohio Journal of Science 52(5): 296, September, 1952.

End view. The external end view of this ootheca presents a double oval-convex outline, with the sides curving inward dorsally as a rounded arc, then extending upward into the seam, while the lower walls extend more deeply (with a less extensive degree of curvature) and merge caudally to form the narrow rounded wall which surrounds the lower ends of the eggs. The external features of the two extremities are as follows:

The *proximal* end—the cell-bearing hollow portion of the seam terminates rather abruptly in a widened and flattened structure which consists of two broad, only slightly elevated ridges paralleling a faint median groove (fig. 4). This groove disappears as the lateral ridges merge and fade into the end curvature.

The *distal* end—the cell row terminates in a sharp, slightly elevated narrow ridge which extends down the continuation of the broader basal portion of the seam (fig. 5); both the ridge and seam base fade out at the point of mergence with the reversed sigmoid curvature described above. The minute ridges of the side walls which parallel the seam base terminate at the margins of the seam-end elevations, a condition which is found also on the opposite end.

Seam. From the side this structure is extremely small when compared to the total size of the capsule, appearing only as a minute crest along the dorsal margin (fig. 1). The top outline of the keel is regularly produced upward into noticeably rounded elevations which, in the center of the seam, have a length of about one-half that of the slightly concave seam spaces between them; these elevations are spaced more closely at the ends of the seam. A minute lateral ridge extends along the length of each side of the seam (fig. 3), the top of which is just below and parallel to the upper margin of the median ridge; these down-set ridges are quite pronounced along the spaces between elevations but tend to fade out or merge somewhat with the bases.

The structural details and seam contents are revealed in strong transmitted light (figs. 2, 3). Each elevation is occupied by a hollow cell which is located high within the walls of the tooth, giving the impression of being perched on top of the seam proper. Each cell is longer than deep and is evenly oval or egg-shaped in outline. A minute hole penetrates each side wall of the cell, forming a direct outside connection. A hollow tube of exceedingly small diameter curves downward from the distal end of each cell; the tubes extend down to the tops of the enclosed white bodies, which are seen in silhouette in this view. In all capsules there is a cell for each egg enclosed within the capsule; in some, however, additional cells were found in the terminal portions of the seam. Most of the capsules examined contained twelve eggs but in a few of these as many as fifteen cells were present in the seam.

The top view of the seam (fig. 6) reveals a narrow face bounded laterally by the minute low-lying ridges described above; the center of the face (and the line of dehiscence) is shown by a sharp elevated median ridge which is interrupted at regular intervals by the cell-bearing elements. These are indicated by oval-lateral as well as by upward extensions of the seam walls. A slight groove is found on either side between the median and lateral ridges; these are quite pronounced in the spaces between the elevations but are greatly reduced on the bases of the latter. The lateral outlines of the white bodies may occasionally be seen as irregular lines paralleling the seam face.

INTERNAL

Seam. When one of the seam walls is removed (fig. 2), the lumen contents and the inflexed face of the opposite seam wall are revealed. The latter is relatively thick in the upper portion but tapers to a very thin blade-like extension into the lumen. The mesal surface of each face is engraved with one-half of each cell and tube system. The capsule and seam wall material is relatively thick and is brittle and hard.

The median line of the seam floor is occupied by a row of sponge-like bodies similar in appearance and apparent composition to those found in the oothecae of *Blatella germanica* L., and *Parcoblatta pennsylvanica* DeGeer. They are upright in position and, in most of the capsules examined, extend upward sufficiently so that the dorsal surface of each is in direct contact with the lower margin of the inflexed seam faces and with the top of the seam lumen. Each body is in direct contact with the tube which leads to a hollow cell above; each, also, is in turn associated with the cephalic end of an egg below, apparently by way of a thin mesal extension down to a sub-floor layer which caps the eggs. There is one such structure included within the seam for each egg enclosed in the main body below; the adjoining ends of these structures are firmly anchored to the sub-floor layer through the median (seam floor) slit and into minute pit-like invaginations which are located between the choria of adjoining eggs directly beneath; they are also attached longitudinally to the layer on top of the eggs.

In cross-section the lumen of the seam is found to be triangular in outline with slightly rounded basal angles and with the apical occupied in part by a short, rapidly tapering inverted triangle representing the abutting inflexed seam faces. In the area between cells, the top of this triangle is quite thickened (fig. 7); a section through a cell (fig. 8) reveals an evenly rounded space, enclosed by extremely thin lateral and dorsal walls, perched on top of a thicker seam-wall base.

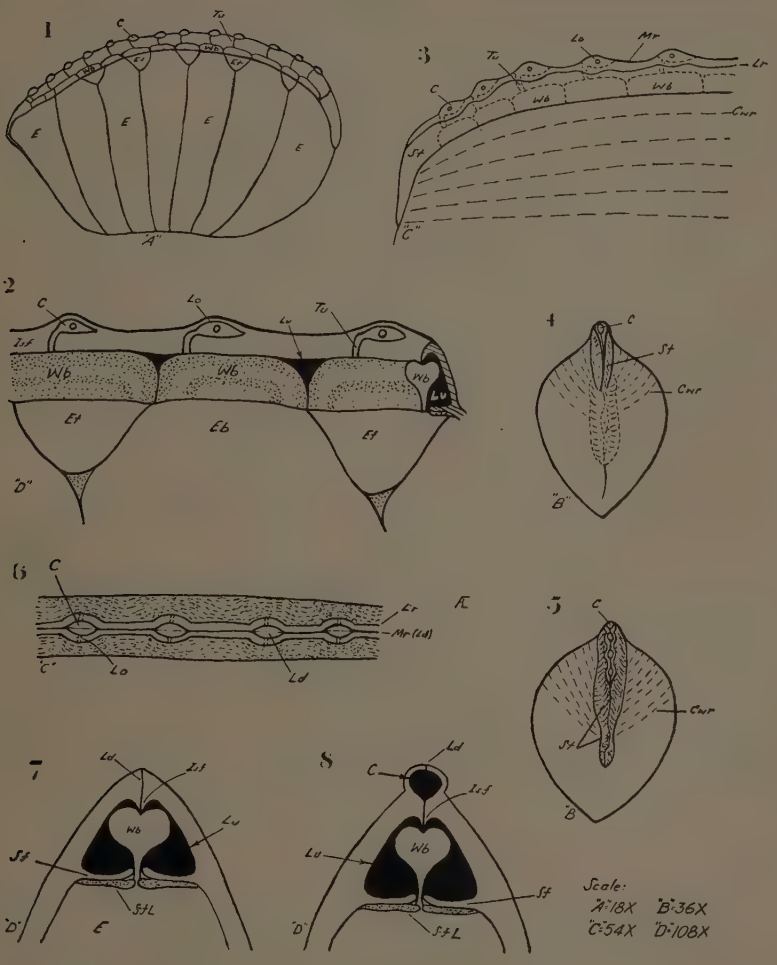
The two halves of the seam floor, or inner laminae of the capsule wall, almost meet on the mid-line (fig. 7); the thickness of each is greatest at its point of separation from the main capsule wall, then tapers irregularly toward the center. The top surfaces are comparatively smooth, while the lower slope upward toward the mesal, slightly upcurved terminations. In this small species the sub-floor layer, which corresponds to that found in *B. germanica* and others, is slightly uneven in thickness and presents an uneven lower or inner outline (fig. 8); in most of the capsules studied, this layer is the same width as the seam floor but occasionally may appear not to extend to the lateral margins of the seam base.

Eggs. The spacing of the eggs is such that the alternate crossing-under arrangement beneath the seam floor is in agreement with that which has previously been found in the oothecae of certain other species of the sub-family Pseudomopinae. The hatched capsule reveals the alternately placed double row of empty egg shells, a condition which also appears to be typical of the egg cases of this subfamily.

No trabecular pattern was found, however, which represents a major departure from egg cases previously examined. Since this pattern, hexagonal in nature when present, represents the impressions of the ovarian cells which secreted the chorion layers (Wheeler, 1889), the assumption here is that the secreting cells in the ovarian tubes of *C. lutea lutea* are either so small as to leave no impression or that such depressions, if present, are too small for resolution with the ordinary compound microscope. The chorion characteristics were studied after removal of the egg contents with carbon tetrachloride; otherwise the material boiled out and was immediately congealed by the heat of the microscope lamp.

EXPLANATION OF FIGURES IN PLATE

1. Side view of ootheca of *Cariblatta lutea lutea* S and Z.
2. Internal side view of portion of seam, one wall removed.
3. External side view of seam and upper part of capsule wall.
4. End view, proximal.
5. End view, distal.
6. Dorsal view of seam.
7. Cross-section of seam between cells.
8. Cross-section of seam through cell.



KEY TO ABBREVIATIONS

C—Cell
Cwr—Capsule wall ridge
E—Egg
Eb—Egg body
Et—Egg termination
Isf—Inflexed seam faces
Ld—Line of dehiscence
Lo—Lateral opening
Lr—Lateral ridge
Lu—Lumen of keel
Mr—Median ridge
Sf—Seam floor
S-f L—Sub-floor Layer
St—Seam termination
Tu—Tube
Wb—White body

Capsule wall. At 440X under a compound microscope the crystalline matrix of the capsule wall was seen; the field, even at this magnification, was full of hundreds of mostly minute square crystals. Scattered sparsely through the field, however, were a few crystals of four to six times the size of the smaller ones.

SUMMARY

The ootheca of *Cariblatta lutea lutea* (S and Z) is described; this variety of a species belonging in the Pseudomopinae produces an egg-case basically similar to that of the common German Roach, *Blatella germanica* L., also of that subfamily.

The capsule is boat-shaped when seen from the side; the seam-bearing dorsal margin is curved, longer than the lower margin, and is connected with the latter by sharply back-curved ends. The seam is very small compared to the remainder of the egg case. The upper walls are marked with minute ridges which parallel the seam base and terminate on the sides of slightly raised structures marking the ends of the seam.

The seam contains hollow cells placed high in the walls; these are punctured laterally by minute holes and are connected with the lumen by way of very fine tubes. Inflexed seam faces carry the tubes down to make contact with spongy white bodies which are aligned in such manner that the position of each corresponds to that of an egg beneath the seam floor. A thin, apparently amorphous layer connects the white bodies with the tops of the eggs.

The eggs are arranged in the manner typical of this group of roaches; i.e., the mesal margin of each extends beneath and slightly beyond the seam floor. When hatching occurs, the seam halves are lifted away with the walls, and the dorsally opened upright egg shells ("pockets") remain in place.

Hexagonal trabecular egg-shell patterns were not found. A few large and great numbers of minute square to rectangular crystals were observed in the matrix of the capsule walls.

These oothecae averaged 1.5 x 3 mm in size.

LITERATURE CITED

Blatchley, W. S. 1920. Orthoptera of Northeastern America. Nature Pub. Co., Indianapolis, Ind.

Lawson, F. A. 1951. Structural features of the oothecae of certain species of cockroaches. Annals Ent. Soc. Amer., 44: 269–285.

Wheeler, W. M. 1889. The embryology of *Blatta germanica* and *Doryphora decemlineata*. Jour. Morph., 3(2): 291–386.

Insect Natural History. *A. D. Imms.* The Blakiston Co. Philadelphia, New York, Toronto. First Edition. 1951. xviii+317 pp. $5.00.

The author presents in an interesting and non-technical manner many of the diverse phases of insect life. One should be able to read this volume easily without technical knowledge of entomology. The chapter on insect structure and transformation gives, in about twenty pages, a remarkably adequate coverage of fundamentals in these phases. Insect classification and nomenclature are very briefly discussed in line with the author's purpose of producing a non-technical volume. Sections on insect flight, sensory physiology, food habits, biological control, gall formation, means of protection, reproduction, aquatic adaptations and social life of insects follow. Important facts and concepts concerning each of these topics are briefly and clearly presented and beautifully illustrated by examples chosen from common insects of the British Isles.

The book contains seventy-two excellent plates depicting common British insects; thirty-two in black and white and forty in color. The species chosen have close relatives in the United States, so that American students should have no difficulty in recognition of the forms and proper association of the text material. The book will serve as a valuable reference on insect life for beginning students in biology, zoology and general entomology. As a text in entomology, it would have to be supplemented by additional material on classification and identification. Altogether this delightful, well-written book is well worth reading.

W. C. Stehr

BOOK NOTICES

Physical Geography. *Arthur N. Strahler.* John Wiley & Sons, Inc. New York. First Edition. 1951. ix+442 pp. $6.00.

Physical Geography by Strahler is a much needed modern text for a course in physical geography. Whereas most of the recent texts that deal with earth science disciplines have been incorporated with cultural and human geographic factors, this one departs from that modern trend in pertaining only to the physical. Written by a geomorphologist, it will find favor with many but will be criticized by those geographers who hold to the premise that all geography must interrelate the physical with the cultural and human aspects.

This well-written book, with one major exception, places adequate emphasis upon the various earth science topics. The illustrations are many and excellent. Numerous exercises to supplement the reading will enable students to better understand the material presented.

The reviewer feels that the section on climate constitutes the weakest part of the book. In an attempt to get away from climatic classifications with complex formulas and the resulting clear-cut boundaries between various climate types, over-simplification has resulted which may leave the reader with a hazy idea of the climatic types of the world. Neither in written material nor in the use of maps does one get a clear picture of where these various climates are located.

The author has been extremely successful in achieving his goal of writing a text which adheres to the disciplines of the physical sciences. It is highly recommended for those introductory and general courses which place the emphasis upon the elements of physical geography. However, if the course is designed to combine the physical principles with the social and cultural phases of geography, this text would serve better as a reference work.

JOSEPH C. BUFORD

Mineralogy. *E. H. Kraus, W. F. Hunt* and *L. S. Ramsdell.* McGraw-Hill Book Co., New York. Fourth Edition. 1951. ix+664 pp., illustrated. $7.50.

The fourth edition of this widely known text is a volume essentially for the embryo mineralogist. Those who have used the older edition will find no extensive revision.

The first nine chapters present a fine discussion of crystallography, but the pictures of the solid crystals models lack depth. Chapters X to XIII deal thoroughly with the external and internal physical properties of minerals, including sections on basic optical mineralogy, crystal structure and X-ray analysis, and chemical properties. Chapters XIV and XV adequately discuss the formation and occurrence of minerals, and techniques of blowpipe identification. The description of minerals in Chapter XVI is useful reference material; the same might be said of Chapter XVII on gemstones. Chapter XVIII provides reference on classification of minerals according to elements.

A glossary of terms, tables of symmetry, tables of mineral determination and a selected bibliography will prove useful as study aids. Some instructors have expressed the opinion that these tables are difficult to use.

The book is unusually broad in scope and extensively illustrated. Some of the illustrations, however, are poor in quality, perhaps due to the use of worn plates.

C. N. SAVAGE

Stratigraphy and Sedimentation. *W. C. Krumbein* and *L. L. Sloss.* W. H. Freeman Co. San Francisco. 1951. ix+497 pp. $5.00.

Most geologists will welcome reintegration of these subjects as treated by the authors of this text. Students of sedimentology may decry the lack of the hypermathematical approach usually found under the name of Krumbein, but most geologists outside that field will applaud the somewhat simpler, though insistently quantitative methods of this book.

The book is designed primarily as a text for advanced undergraduate and beginning graduate students, but since it condenses and synthesizes those studies of sedimentation which are most closely related to stratigraphy, it should find a place in the reference library of many practicing stratigraphers. Teachers of stratigraphy who feel that a course in the subject should not be simply a recital of classical sections and type localities will find a stimulating approach in this book. Senior students with a good background in geology and allied fields find the text to be readily comprehended. Those engrossed in sedimentary petrology will find little of interest.

The authors present no new techniques or hypotheses. However, information formerly available only to specialists in certain fields has been clearly explained in this text and thus made useful to others. The book is, in short, sedimentation for stratigraphers.

The development is logical. Basic procedures of field stratigraphy are first reviewed, followed by a brief discussion of sedimentary petrology and processes, leading to the interpretation

of sedimentary environments. The introduction of stratigraphic paleontology follows, which in turn brings up the problems of facies and correlation. The final part of the book deals with the study of regional tectonics which serves as a framework for the interpretation of paleogeography. The final chapter, entitled "Paleogeography" represents only a variation on themes stated in earlier chapters. It would seem that this topic could be either completely integrated into the other chapters or treated in somewhat more detail.

Advanced students and research workers will value the extensive bibliography, containing over 500 entries. Supplementary readings listed at the end of each chapter suggest additional studies for advanced students.

Finally, the Freeman Company must be complimented for the pleasing appearance of the book. Typographical errors are few.

HENRY H. GRAY

Taxonomy of Vascular Plants. *George H. M. Lawrence.* Macmillan Co. New York. First Edition. 1951. xiii+823 pp. $7.95.

For the first time all existing essential data on the taxonomy of vascular plants is appropriately gathered together in one well-composed and scholarly written volume.

The author's treatment of historical background, the tenets of plant nomenclature and the several codes adhered to by those who will classify plants is both masterful and interesting.

The sections on plant identification and field and herbarium techniques include in a large measure most of the current methods practiced by the technicians and curators of the larger herbaria both internationally and in the United States. The text is further enhanced throughout by clever suggestions and criticisms of the author who quickly points out faults and disadvantages in methods, techniques, collecting, mounting media, devices, etc.

An innovation in taxonomic literature is encountered in Part I of the book in which the author skillfully analyzes the strong linkages and interdependence of taxonomy with other well-established branches of modern science.

The author clearly demonstrates the importance of a paleobotanical foundation to a natural scheme of any fundamental classification. Familes are arranged according to the Engler System (1936).

An excellent glossary in the Second Appendix adequately explains the terminology which includes some new but accepted usage. An outline of an elementary course in taxonomy has been inserted for the convenience of the teacher.

The text, far in advance of anything published in the field of taxonomy, should enjoy wide adoption for it is ideally suited to the needs of both student and teacher.

A. H. BLICKLE

A Laboratory Guide to the Anatomy of the Rabbit. *E. Horne Craigie.* University of Toronto Press. Toronto. 1951. First Edition. viii+113 pp. $2.75.

This book, though less detailed than its well-known predecessor (Bensley's "Practical Anatomy of the Rabbit"), is no less useful in the field of Comparative Vertebrate Anatomy. In fact, it may find more widespread use as a laboratory guide in its present form, especially in courses which are designed to cover representatives of vertebrate classes beyond the mammal. Professor Craigie has produced a manual which is far more readable than Bensley's and at the same time has lost none of the most important points with respect to mammalian anatomy.

Dr. Craigie's typically clear, concise presentation makes this text useful for both classroom and independent work. No vertebrate anatomy reference library is complete without this book and its companion volume mentioned above. The author has organized the text material according to organ systems and secondarily according to regions; he has also presented his material with a view to the functional aspect of anatomy.

FRED H. GLENNY

Atomics Physics. *Wolfgang Finkelnburg.* (George E. Brown, translation). McGraw-Hill Book Co., Inc. New York. First Edition. 1950. x+498 pp. $6.50.

The scope of this book is more ambitious than one would imagine from merely reading the title. One finds, in addition to the subjects usually associated with atomic physics, discussions of molecular physics and the liquid and solid state. This broad coverage necessitates a concise treatment of all the topics covered. However, the well-organized topics are complete enough so that one with some background in physics and mathematics could follow the trends of thought without great difficulty. This feature should prove especially interesting for those in related fields who have fallen behind in the rapid pace we have been traveling and desire to catch up with a minimum of wasted effort. A bibliography follows at the end of each chapter. In the

text material recognition is given to those investigators who have made important contributions to the subject at hand. However, reference to original source material is lacking.

Space being at a premium, the author at times takes short cuts in mathematics, for example, the derivation of the change in wavelength of a quanta in Compton scattering. A derivation for the wavelength shift is made without taking into account the relativity correction for the mass of the recoil electron. The author contends that the simple derivation gives the same results as the rigorous relativistic derivation. However, he did not mention the errors introduced in the approximation, how they cancelled out or why we ever should bother with the more rigorous derivation since it gives the same results.

The author does a good job interrelating various ideas in the field and in tracing the interlinking of experimental results, their apparent inconsistencies, and the resulting changes in theoretical concepts which were forced upon the scientists by these apparent contradictions.

EDWARD S. FOSTER, JR.

Elements of World Geography. *J. Riley Staats* and *G. E. Harding*. D. Van Nostrand Company. New York. 1951. vi+378 pp., maps, illustrations, questions, index. $4.25.

This book represents another addition to the extensive list of texts designed for introductory courses in geography. It is designed to meet the needs of a full semester of geography at the college level.

The arrangement of the book is characteristic of many texts dealing with similar material. The elements of the physical environment are analyzed in a systematic fashion. Instead of being divided into two sections like many introductory texts, it is based on a systematic analysis of the more important physical aspects with an attempt to integrate cultural features pertinent to each phase. The authors provide a very general and understandable treatment of the major physical aspects but definitely neglect many human or cultural relationships in a number of chapters.

The text includes some good photographs and a number of sketches and maps adequate for ease of interpretation. A larger selection of photographs would prove a helpful addition.

The book should be highly adequate for use as a beginning college text or even at the senior high school level if a systematic approach is desired and if the teacher feels a need for emphasizing the physical aspects.

With all the minor limitations of this text, it seems to give a reasonably understandable treatment without too much highly technical vocabulary. It should be easily adaptable to a fairly wide range of teacher interests and abilities.

JAMES RINIER

Experiments in Biochemistry. *Max S. Dunn* and *William Drell*. McGraw-Hill Book Co., Inc. New York, Toronto, London. 1951. First Edition. viii+198 pp. $5.00.

Drs. Dunn and Drell are to be commended for this stimulating and up-to-date laboratory manual in biochemistry. It offers a wealth of interesting experiments to the beginning student in this field. The forty-six exercises presented allow each instructor wide latitude in the choice of his course material. They are diverse and in several instances, new and unusual. They offer the student opportunity to gain experience in the synthesis, isolation, purification and analysis of typical biochemical compounds and in the quantitative determination of biological substances in a variety of naturally occurring materials.

Syntheses of nine compounds are described including the preparation of phenylalanine, glycine anhydride, glycylglycine and tyramine hydrochloride and an asymmetric enzymatic synthesis of aceyl-L-phenylalanine-p-toluidide which permits the separation of D- and L-phenylalanine.

Directions are given for the isolation of a number of substances from natural sources including asparagine from lupine sprouts, cholesterol from beef spinal cords and L-arabinose from mesquite gum.

Approximately half of the experiments are quantitative in character. In addition to standard gravimetric, volumetric and colorimetric analyses, the authors have included an amide-nitrogen determination using asparagine, polarimetric analyses of L-cystine and of D-lactose, a chemical assay of Vitamin C, a biological assay of Vitamin D and microbiological assays of nicotinic acid and of choline.

A novel exercise involving the separation and identification of purines and pyrimidines using paper chromatography should prove valuable as an introduction to this new and widely used technique.

Detailed discussions of the principles and techniques employed in each experiment are presented. The appendix includes more than nine hundred references to the original and review literature as well as a list of apparatus needed for the course; it also summarizes amounts of reagents and supplies required per student for each experiment.

HAROLD G. ODDY

ENROLL A NEW MEMBER

The Ohio Academy of Science was organized on December 31, 1891, at Columbus, was incorporated on March 12, 1892, and became affiliated with the American Association for the Advancement of Science early in 1920. Its membership has grown from 59 charter members to more than 1200. The membership is representative of the educational and scientific institutions of the State and includes quite a number of persons outside the State.

AIMS—According to the Constitution: "The objects of this Academy shall be the promotion of scientific research and the diffusion of knowledge concerning the various departments of science." In addition to research and publication, the Academy aids in securing legislation which is favorable to scientific projects, as conservation, topographic and geologic survey, and in other important scientific projects.

MEMBERSHIP—Membership is open to all persons interested in science. Members engaged in scientific work may be elected "fellows." Each member receives *The Ohio Journal of Science* and the publications of *The Ohio Biological Survey* for the regular annual dues of $3.00. Institution and corporation memberships are also open to such organizations in the state.

SECTIONS—Each member is enrolled in *one* section for voting purposes, but is privileged to participate in the program of any section. To avoid excessive subdivision into sections as new fields of research develop, symposia which may cut across several fields of interest are scheduled at the annual meeting at hours which permit attendance of persons from various sections. Sections are listed below.

A—Zoology	E—Psychology	I —Mathematics
B—Botany	F—Physics & Astronomy	J —Science Education
C—Geology	G—Geography	K—Anthropology & Sociology
D—Medical Sciences	H—Chemistry	L—Conservation

MEETINGS—Annual meetings are held at a time and place fixed by the Executive Committee and the Council on the basis of invitations extended by educational institutions presented at the previous annual meeting. A regional plan is followed, so all areas of the state are covered over a period of several years. In addition to the program of scientific addresses and papers, field trips are frequently arranged.

OFFICIAL ORGAN—From 1892 to 1903, the *Journal of the Cincinnati Society of Natural History* and the technical series of *Bulletins of the Ohio Experiment Station* were the official organs of the Academy; in 1903 the *Ohio Naturalist* was made the official organ and continued as such until 1915 when the *Ohio Journal of Science* became the official organ. Its columns are are open to members of the Academy for special contributions, subject to acceptance by the Editorial Board. Articles in all scientific areas appear in the *Journal*.

RESEARCH FUND—From 1898 to 1922, through the generosity of M. Emerson MacMillan, of New York, a fund was available annually for encouragement of research among the Academy members. An accumulation from this grant together with the annual grant from the A.A.A.S. makes grants for research available to Academy members. This fund is administered by a committee known as the Trustees of the Research Fund.

INFORMATION—Requests for information concerning any part of the Academy program should be addressed to the Secretary, who will either send a reply or will forward the request to the proper person for reply. The current Secretary is:

DR. RUSH ELLIOTT, Ohio University, Athens, Ohio.

THE OHIO ACADEMY OF SCIENCE
(Affiliated with the A.A.A.S.)

_____, 19____

I desire to become a Member of the Ohio Academy of Science. It is understood that my membership will begin immediately. Dues are attached* according to one of the following plans:

1. Application dated before July 1, $3.00 dues for current year, Jan. 1 to Dec. 31, with all copies of The Ohio Journal of Science for the year.
2. Application dated after July 1, *check one option:*
   - ☐ $3.00 dues for current year, Jan. 1 to Dec. 31, with all copies of The Ohio Journal of Science for the year; or
   - ☐ $1.50 dues for last half of current year, July 1 to Dec. 31, with copies of The Ohio Journal of Science for last six months only.
3. Corporation and Institution Memberships—$25.00 dues for the current year with copies of The Ohio Journal of Science for the year.

Name Dr. Mr. Miss Mrs. Corp. Inst. _____
(Check title preferred. Please print name)

Address _____ City _____
(Print preferred mailing address)

Institution Affiliation _____

I wish to enroll and vote in Section _____ (one section only—see above).

*Make check payable to The Ohio Academy of Science, and mail to Dr. R. M. Geist, Treasurer, Capital University, Columbus 9, Ohio.